Sizewell C Project

Radioactive Substances Regulation (RSR) Permit Application

Appendix D

Support Document D2 - Non-Human Biota Radiological Impact Assessment

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EXECUTIVE SUMMARY

NNB Generation Company (SZC) Limited (SZC Co.) plan to construct and operate a new nuclear power station comprising two UK EPR™ units and associated infrastructure near Sizewell in Suffolk. The proposed nuclear power station, known as Sizewell C (SZC), will be situated to the north of both Sizewell B (SZB) and Sizewell A (SZA) nuclear power stations which are operational and defueled respectively.

This report provides an assessment of the potential radiological impacts to flora and fauna from Normal Operational Radiological Discharges (both gaseous and aqueous) from the proposed SZC nuclear power station and in combination with discharges from the SZB power station. The assessment was based on the proposed annual discharge limits for SZC, and the permitted discharge limits for the neighbouring SZB facility were used in the assessment of in-combination effects.

The potential impacts on a range of organisms representative of those inhabiting the areas close to the facility have been assessed. For all of the organisms evaluated, dose rates (biological impacts of ionising radiation) remained substantially lower than the Environment Agency current assessment threshold of 40 µGy/h. The dose rates were also lower than broader internationally considered thresholds. These included the:

- Environmental Risk from Ionising Contaminants: Assessment and Management (ERICA) screening value that is considered protective of populations of Non-Human Biota (NHB) across all ecosystems (10 µGy/h); and
- Derived consideration reference levels, the most stringent of which is 4 µGy/h (for the duck, rat, deer and pine tree Reference Animals and Plants (RAPs)), applicable to planned exposure situations.

The assessment results have shown the dose rate from SZC discharges to the worst affected organism (polychaete worm occupying a marine habitat) to be 0.80 µGy/h, with a risk quotient value (RQ, the ratio of the estimated dose rate to the assessment threshold of 40 µGy/h) of 0.020. The worst affected organism from the combined discharges of radioactive effluent from the SZB and SZC facilities (insect larvae occupying a marshland habitat) was 2.7 µGy/h, with a RQ value of 0.067. These dose rates are more than one order of magnitude below the current Environment Agency threshold dose rate of 40 µGy/h, and well below the ERICA screening value of 10 µGy/h.

The impacts of radioactive effluent discharges on NHB from the proposed SZC nuclear power plant alone and in combination with SZB are therefore predicted to be very low. As such, based on the internationally recognised models used in this assessment, the output of which are well below regulatory threshold levels and furthermore comparable to or below previous assessments undertaken by the Environment Agency for the Natura 2000 sites, it can be concluded that there would be no significant effects on any Natura 2000 site and hence radiological effects are screened out of the Shadow Habitats Regulations Assessment. Likewise no significant effects are predicted on any other ecological receptor or designated site, such as Site of Special Scientific Interest (SSSI).

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1.1 Purpose

1. SZC Co. plan to construct and operate a new nuclear power station comprising two UK EPR™ units and associated infrastructure near Sizewell in Suffolk. The proposed nuclear power station, known as SZC, will be situated to the north of both SZB and SZA nuclear power stations which are operational and defueled respectively.

1.2 Scope

2. This report provides an assessment of the radiological impacts of Normal Operational Radiological discharges to air and to the marine environment (collectively referred to as permitted discharges) from the proposed SZC nuclear power station on flora and fauna (collectively referred to as NHB). Impacts from the combined discharges of the existing SZB nuclear power station and the proposed SZC nuclear power station were also assessed.

3. This report forms part of the documentation prepared in support of the Radioactive Substances Regulations (RSR) permit application for SZC. The report is also prepared in the context of the SZC Habitats Regulations Assessment (HRA) Evidence Plan, October 2014 [Ref 1] which screened out potential radiological effects on NHB during construction of the proposed power station, but identified a need for a site-specific NHB assessment of representative habitats and species to consider impacts during the operational phase.

1.3 Definitions

Term / Abbreviation	Definition
BSS	Basic Safety Standards
C&M	Care and Maintenance
CEFAS	Centre for Environment, Fisheries and Aquaculture Science
CR	Concentration Ratio
DCC	Dose Conversion Coefficient
EC	European Commission
EMCL	Environmental Media Concentration Limits
EPR16	Environmental Permitting Regulations 2016 (As Amended)
ERICA	Environmental Risk from Ionising Contaminants: Assessment and Management
FASSET	Framework for the Assessment of Environmental Impact
HPC	Hinkley Point C
HRA	Habitats Regulations Assessment
IAEA	International Atomic Energy Agency
ICRP	International Commission on Radiological Protection
Kd	Distribution Coefficients
Met	Meteorological
NHB	Non-Human Biota
SZC Co.	NNB Generation Company (SZC) Limited
NRPB	National Radiological Protection Board
RAP	Reference Animal and Plant

Term / Abbreviation	Definition
R&D	Research and Development
RIFE	Radioactivity in Food and the Environment
RPD	Radiological Protection Division
RQ	Risk Quotient
RSR	Radioactive Substances Regulations
SAC	Special Areas of Conservation
SCI	Site of Community Importance
SPA	Special Protection Area
SSSI	Site of Special Scientific Interest
SZA	Sizewell A
SZB	Sizewell B
SZC	Sizewell C
UF	Uncertainty Factors

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[2]	The Environmental Permitting (England and Wales) Regulations 2016	1154	-	http://www.legislation.gov.uk/uksi/2016/1154/pdfs/uksi_20161154_en.pdf	Statutory Instruments
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1.5 Overview of Regulatory Framework

4. The proposed SZC nuclear power station will make operational discharges of aqueous and gaseous effluent into the environment under specific limits and conditions stipulated in an environmental permit granted under Schedule 23 of the Environmental Permitting (England and Wales) Regulations 2016 (as amended) (EPR16) [Ref 2] also known as the Radioactive Substances Regulations.

5. The Environment Agency has obligations under the European Union Wild Birds and Natural Habitats Directives [Ref 3] to ensure that no Environment Agency permitted activity results in an adverse effect,

either directly or indirectly, on the integrity of Natura 2000 sites[1] [Ref 4]. The Environment Agency is also required to ensure that the integrity of Natura 2000 sites is not adversely impacted by any new (or variation of existing) permits they issue [Ref 3].

6. Furthermore, one of the key environmental principles underpinning the RSR in the UK is the provision of adequate protection to non-human species from exposure to ionising radiation [Ref 5]. The Environment Agency requires key species that need protection in particular habitats, and key habitat features to be identified and that the dose rates to such species estimated and compared to the current guideline dose rate of 40 µGy/h [Ref 4] [Ref 5].

7. The above requirements have been implemented as part of the requirements for an environmental permit under the RSR regime in respect of nuclear sites. Permit applicants are required to carry out a prospective assessment of dose rates to NHB alongside human dose assessment as part of the permit application process.

8. The assessment of potential impacts of radioactive discharges on NHB has been embedded in the Basic Safety Standards (BSS) Directive (2013/59/Euratom), adopted on the 5th December 2013 [Ref 6][2]. The BSS Directive, which implements the latest recommendations of the International Commission on Radiation Protection (ICRP) [Ref 7], recognises that 'the contamination of the environment may pose a threat to human health…'and that 'while the state of the environment can impact long-term human health, this calls for a policy protecting the environment against the harmful effects of ionising radiation'. This provision formally introduces the protection of the environment into radiation protection legislation. The BSS Directive has been transposed into UK law in 2018/2019.

1.6 Document Structure

9. This document is set out in the following way:

- Section 2 – Sets out the ecological context in the area around the Sizewell C nuclear power station area.
- Section 3 – Describes the source term used for the dose assessment, including the annual limits proposed for gaseous and aqueous radioactive discharges from the operation of the Sizewell C nuclear power station.
- Section 4 – Dispersion modelling, describing the habitats selected and assessed, including a discussion of the PC-CREAM 08 modelling software used.
- Section 5 – Assessment approach – ERICA integrated approach and the R&F 128 methodology.
- Section 6 – Reference organisms considered in the assessment.
- Section 7 – Results and Discussion, presenting the doses rates due to Sizewell C radiological discharges as well as the combined radiological discharges from Sizewell B and Sizewell C.
- Section 8 – Conclusion, summarises the results and conclusions of the Non-Human Biota Radiological Impact Assessment.

[1] Natura 2000 is made up of sites designated as Special Areas of Conservation (SACs) and Special Protection Areas (SPAs) under Council Directives 79/409/EEC on the conservation of wild birds and 92/43/EEC on the conservation of natural habitats and wild flora and fauna [3].
[2] The new BSS Directive [6] brings together and consolidates the existing EURATOM directives and incorporates the latest recommendations from the ICRP (ICRP Publication 103) [7].

2 ECOLOGICAL CONTEXT

10. The proposed SZC nuclear power station is situated within the Suffolk Coast and Heaths Area of Outstanding Natural Beauty and is surrounded by an ecologically diverse environment comprising designated sites of regional, national and international importance [Ref 1]. SZC Co. have commissioned extensive baseline ecological studies of the terrestrial and marine environments which identified the key sensitive ecological receptors (habitats and species) in the vicinity of the proposed SZC site [Ref 8] [Ref 9]. Some of the key ecological receptors in the vicinity of the site include (see Appendix A for locations of these areas):

- **Minsmere-Walberswick Heaths and Marshes** is a designated SSSI, to the north of the proposed SZC site, part of which is also designated as a Special Protection Area (SPA), Special Area of Conservation (SAC) and Ramsar site. The SPA comprises two large marshes, the tidal Blyth estuary and associated habitats and contains areas of marsh with dykes, extensive reedbeds, mud-flats, lagoons, shingle, woodland and areas of lowland heath. It supports nationally important numbers of breeding and wintering birds including Bittern (*Botaurus stellaris*), Marsh Harrier (*Circus aeruginosus*) and a range of breeding waders (e.g. Avocets *(Recurvirostra avosetta)*) [Ref 10]. The shingle beaches support important numbers of Little Tern (*Sterna albifrons*), which feed substantially outside the SPA in adjacent marine waters, and is important for wintering Bitterns and raptors [Ref 10]. In addition to the habitats identified in the SPA, the SSSI also contains heathland and grazing marsh. There is extensive Lowland European dry heaths dominated by heather (*Calluna vulgaris*), but also containing bell heath (*Erica cinerea)* and cross-leaved heath (*E. tetralix)* [Ref 11]. Shingle beach forms the coastline at Walberswick and Minsmere, which supports a variety of scarce shingle plants including sea pea (*Lathyrus japonicus*) and sea campion (*Silene maritima*) [Ref 11].

- **Sizewell Marshes SSSI** lies immediately to the north and to the west of the SZC site and a small part of the proposed site lies within the SSSI. The SSSI comprises a range of wetland habitats including grazing marsh, open water and fen meadow, supporting a variety of assemblages of invertebrates including terrestrial and aquatic beetles (*Coleoptera*), flies (*Diptera*), moths (*Lepidoptera*), dragonflies (*Odonata*) and spiders (*Araneae*) [Ref 12]. The site is also important for breeding birds, especially those typical of wet grassland and related habitats such as Shoveler, Gadwall, Teal, Snipe and Lapwing [Ref 12].

- **Leiston-Aldeburgh SSSI** [Ref 13] **and Sandlings SPA** [Ref 14] to the south and south west of the Sizewell site. The SSSI comprises a mosaic of habitats including acid grassland, heath, scrub, woodland, fen, open water and vegetated shingle, and supports a diverse and abundant community of breeding and overwintering birds, a high number of dragonfly species and many scarce plants [Ref 13]. The SPA is characterised by remnant of heath, interspersed with bracken (*Pteridium aquilinum*), shrubs and trees. The heaths support both acid grassland and heather-dominated plant communities with dependent invertebrate and bird communities of conservation value – including Woodlark (*Lullula arborea*) and Nightjar (*Caprimulgus europaeus*), which have adapted to breeding in the surrounding areas of conifer plantations and open ground [Ref 14].

- **Outer Thames Estuary SPA to the east of the Sizewell site** is classified for the protection of the largest aggregation of wintering red-throated diver *(Gavia stellata)* in the UK, and for the protection of little tern (*Sternula albifrons*) and common tern (*Sterna hirundo*) [Ref 15]. The SPA lies along the east coast of England in the southern North Sea and extends northward from the

Thames Estuary to the sea area off Great Yarmouth on the East Norfolk Coast. The Outer Thames Estuary SPA overlaps with a candidate SAC/Site of Community Importance (SCI) that has been identified for the protection of Harbour porpoise – the Southern North Sea cSAC/SCI.

11. In order to gather appropriate and aligned data typical of the major environment the ICRP has developed a set of RAPs. Five indicative habitats representative of designated areas found locally around the proposed SZC site have been identified as potentially sensitive to radiological impacts due to their ecological significance and their location relative to the site of the proposed SZC facility [Ref 16][3]. These are:

    - **Habitat 1**, a terrestrial habitat, representative of Sizewell Marshes SSSI, lies adjacent and to the west and north of the Sizewell site. This terrestrial habitat was selected as it will experience the highest air concentrations and deposition due to both the proximity to the site and being in the direction of maximum air concentrations (as modelled in PC CREAM, see Section 4). The dose rates calculated will therefore be the highest of the terrestrial habitats of interest.

    - **Habitat 2**, a marine habitat, representative of the Outer Thames Estuary SPA area to the east of the Sizewell site.

    - **Habitat 3**, a coastal habitat, representative of the area to the north of the Sizewell site within the Minsmere-Walberswick Heaths and Marshes SSSI, SPA and Ramsar includes both shoreline and the adjacent terrestrial area. This habitat is therefore assumed to be impacted by both aqueous and gaseous discharges.

    - **Habitat 4**, a freshwater habitat, representative of the scrape in the centre of Minsmere Nature Reserve, within Minsmere-Walberswick Heaths and Marshes SPA.

    - **Habitat 5**, encompasses a mixed habitat representative of the marshland within the Minsmere-Walberswick Heaths and Marshes SSSI, SPA and Ramsar.

12. With the exception of Habitat 3 (coastal habitat), the habitats described above are broadly consistent with the default ecosystems within the ERICA tool used to assess the impact of radiological discharges on NHB (described in later sections). The coastal habitat is a mix of terrestrial and marine habitats, such as those of Habitats 1 and 2 above. The aggregate radiological impacts to the organisms for Habitats 1 and 2 were therefore considered to be bounding for those occupying Habitat 3. Some organisms can move between different environments, and as such can be exposed in more than one environment. However, ERICA only considers birds and mammals in both the marine and terrestrial habitats; the other organisms are considered to inhabit one or the other habitat. Since the mammals considered are different (a rat or deer on land and a porpoise in water), movement between the two habitats is not considered for mammals. Movement between different habitats has been considered for bird species, i.e. for semi-aquatic birds such as the Gadwall, by assuming a 50/50 occupancy in terrestrial and marine environments.

13. The models and approaches described in further detail in Section 5 do not consider the specifics of whether the environment is marine, acid heath, chalkland heath, acid bog, marsh etc. Rather, only generic biota types and their general ecological behaviour (e.g. proportion of time on ground or within ground etc.) are considered. In the ERICA modelling system [Ref 15], it is possible to modify the 'concentration

[3] The Leiston-Aldeburgh SSSI and the Sandlings SPA are further away from the site than the locations identified as representative for each habitat type and are not in the direction of maximum air concentration and deposition. It is therefore expected that dose rates to organisms at the Leiston-Aldeburgh SSSI or the Sandlings SPA sites will be lower than calculated in this assessment.

ratio' (CR) values that are used to predict the organism body burden relative to an environment concentration (whether in soil or water etc.). Determining site specific CR values is possible, but requires extensive field research involving collection of environmental media and species collection for laboratory analysis. As such, use of default values is appropriate unless the resultant dose is above the screening values, which would warrant a site specific investigation to determine the level of conservatism in the assessment.

14. This is in line with International Standards and Best Practice. In the assessment, the CR values were generic values for the terrestrial environment, set as default within the ERICA assessment tool, and derived from the International Atomic Energy Agency (IAEA) TRS 479 [Ref 17]. CRs were recognised as being a key area of uncertainty in assessments with large variability in values being observed for different soils (see for example Smith et al. [Ref 18]). However, noting the resultant dose rates for terrestrial biota were several orders of magnitude below the current Environment Agency assessment threshold of 40 µGy/h (ca. 4 orders of magnitude), variation in the CR values are unlikely to result in dose rates above the threshold. The generic values are therefore sufficient for this scenario and any sensitivity associated with the CR does not require further consideration.

3 SOURCE TERM

15. Discharges of aqueous radionuclides into the marine environment will be made via outfall structures to be constructed at two locations approximately 3.5 km distance offshore with OS grid references (651080, 264125) & (651155, 264125) within a local compartment of the North Sea [Ref 19]. Releases of gaseous radionuclides into the atmosphere will be made via two emission stacks with physical heights of 70m, protruding approximately 10m above the reactor buildings housing the two UK EPR™ units [Ref 20].

16. The assessment considers discharges at the proposed annual limits. Table 3-1 and Table 3-2 present the proposed annual limits for discharges of aqueous and gaseous radionuclides from the SZC facility, along with expected best performance values.

17. The cumulative impacts of the combined discharges from SZC and the neighbouring SZB facility on NHB were also assessed. The discharge limits and reported annual discharges for the SZB facility were taken from the three most recent Radioactivity in Food and the Environment (RIFE) Reports as compiled by the Centre for Environment, Fisheries and Aquaculture Science (CEFAS) on behalf of the UK Environment Agencies [Ref 21] [Ref 22] [Ref 23] and are presented in Table 3-1 and Table 3-2.

18. SZA is defueled and is expected to have entered into the Care and Maintenance (C&M) phase before the proposed SZC facility begins power generation [Ref 24. Discharges from SZA have therefore not been considered in the assessment of cumulative site impacts. Any future impacts associated with the decommissioning of SZA or B will be assessed under the Environmental Impact Assessment for Decommissioning Regulations and, where applicable, associated permit variations or applications

Table 3-1 Annualised Aqueous Discharges for Sizewell C and Sizewell B Facilities

Radionuclide	SZC		SZB	
	Proposed limits (Bq/y)	Expected best performance (Bq/y)	Annual discharge limits (Bq/y)	Annual discharges (Bq/y) (based on a 3 year average)
Ag-110m	1.12E+09	7.51E+07	-	-
C-14	1.90E+11	4.60E+10	-	-
Co-58	4.07E+09	2.73E+08	-	-
Co-60	6.00E+09	3.95E+08	-	-
Cr-51	1.18E+08	7.91E+06	-	-
Cs-134	1.10E+09	7.38E+07	1.30E+11	4.50E+09
Cs-137	1.90E+09	1.10E+08	2.00E+10	7.82E+08
H-3	2.00E+14	1.04E+14	8.00E+13	2.39E+13
I-131	9.83E+07	6.59E+06	-	-
Mn-54	5.31E+08	3.56E+07	-	-
Ni-63	1.89E+09	1.27E+08	-	-
Sb-124	9.63E+08	6.46E+07	-	-
Sb-125	1.60E+09	1.07E+08	-	-
Te-123m	5.11E+08	3.43E+07	-	-

Note: SZB is permitted for H-3, Cs-137, and other radionuclides. Here it has been assumed that other radionuclides can be assessed as Cs-134.

19. In the Hinkley Point C (HPC) permit, the Environment Agency assigned annual limits on aqueous discharges of H-3, C-14, Co-60 and Cs-137. Other fission and activation products were grouped together as 'other radionuclides' and assigned a single annual aqueous discharge limit. For the purpose of the SZC radiological assessments, the typical percentage of the individual radionuclides comprising the 'other radionuclides' group [Ref 25] has been applied to derive the annual limits for the individual radionuclides, based on the limits granted for 'other radionuclides' for HPC.

20. The annual aqueous discharges for SZB have been derived as the average of reported discharges for 2015-2017, in order to reduce the effect of annual variations in reported discharges from the station (for instance as a result of shut-down for maintenance or other reasons).

21. SZB has annual limits specified for aqueous discharges of H-3, Cs-137 and 'other radionuclides' [Ref 21] [Ref 22] [Ref 23]. Cs-134 is used as a surrogate for SZB discharges of 'other radionuclides': the dose from this group is estimated by calculating the dose from an equivalent activity of Cs-134. This approach was also used for the HPC RIA [Ref 25], and was therefore used for SZC.

Table 3-2 Annualised Gaseous Discharges for Sizewell C and Sizewell B Facilities

Radionuclide	SZC		SZB	
	Proposed limits (Bq/y)	Expected best performance (Bq/y)	Annual discharge limits (Bq/y)	Annual discharges (Bq/y) (based on a 3 year average)
Ar-41	1.31E+12	4.64E+10	3.00E+13	2.94E+12
C-14	1.40E+12	7.00E+11	5.00E+11	2.33E+11
Co-58	1.09E+07	7.24E+05	-	-
Co-60	1.28E+07	8.54E+05	1.00E+08	7.67E+06
Cs-134	9.98E+06	6.65E+05	-	-
Cs-137	8.95E+06	5.96E+05	-	-
H-3	6.00E+12	1.00E+12	3.00E+12	6.73E+11
I-131	4.00E+08	5.00E+07	5.00E+08	1.30E+07
I-133	7.74E+07	5.16E+06	-	-
Kr-85	6.26E+12	2.22E+11	-	-
Xe-131m	1.35E+11	4.80E+09	-	-
Xe-133	2.84E+13	1.01E+12	-	-
Xe-135	8.92E+12	3.17E+11	-	-

Note: SZB permit specifies limits for noble gases (assessed as Ar-41), particulate beta (assessed as Co-60) and H-3, C-14 and I-131.

22. In the HPC permit, the Environment Agency assigned annual limits on gaseous discharges of H-3, C-14, I-131 and noble gases. Other fission and activation products were grouped together as 'beta-emitting radionuclides associated with particulate matter' and assigned a single annual gaseous discharge limit. For the purpose of the SZC radiological assessments, the typical percentage of the individual radionuclides comprising the noble gases and the grouped radionuclides [Ref 16] has been applied to derive the annual limits for the individual radionuclides based on the limits granted for noble gases and other beta-emitting radionuclides for HPC C.

23. Co-60 is used as a surrogate for SZB discharges referred to as 'particulate beta' in the RIFE Reports [Ref 21] [Ref 22] [Ref 23] in accordance with the approach used for the HPC RIA [Ref 25] [Ref 26]. Dose from 'particulate beta' is therefore estimated by calculating the dose from an equivalent activity of Co-60.

24. It is evident from Table 3-1 and Table 3-2 above that the actual discharges from SZB are significantly below the permitted discharge limits; similarly, the predicted discharges from SZC will be less than the proposed permit limits. The use of annual discharge limit data for the purpose of this radiological assessment therefore represents a bounding assessment, where actual exposure is likely to be lower.

4 DISPERSION MODELLING

25. The dispersion and subsequent environmental accumulation of radionuclides discharged from the SZC facility were modelled using the supporting modules within the PC-CREAM 08 software [Ref 27]. This is a well-established software system used by operators and regulators for human and NHB dose assessment modelling. Site-specific model parameters were used to provide realistic estimates of environmental concentrations arising from radionuclide releases.

4.1 Habitat 1 (Terrestrial Habitat)

26. The dispersion, deposition and build-up of radionuclides from gaseous discharges into the atmosphere were modelled using the PLUME and FARMLAND modules within PC-CREAM 08.

27. PC-CREAM 08 does not account for the entrainment of gaseous releases in the wake of nearby buildings; thus an effective stack height (physical stack height plus wake effects of nearby buildings) has to be determined and input into PLUME [Ref 27] [Ref 28].

28. An effective stack height of 20 m, equivalent to one-third of the height of the adjacent reactor building, has been applied in modelling the atmospheric dispersion of gaseous discharges on the basis of the approach described in National Radiological Protection Board (NRPB) report NRPB-R-157 [Ref 29]. This is widely recognised as a pessimistic approach and is consistent with the approach adopted during the Generic Design Assessment [Ref 30] in the radiological assessments undertaken in support of the HPC permit application [Ref 25].

29. The atmospheric dispersion modelling utilised hourly sequential meteorological (Met) data for the SZC site for the period covering 2003-2012 as supplied by the UK Met Office[4]. These data were provided in the Pasquill stability category format compatible with PC-CREAM 08. These data are presented in Appendix B and have been used to model the air concentration and deposition rates of gaseous radionuclides released into the atmosphere.

30. Discharges of gaseous radionuclides to the atmosphere were modelled using the PLUME model parameters with values summarised in

31. Table 4-1. Deposition of tritium is considered (in accordance with the approach adopted for HPC) using values for deposition velocity and washout coefficient from the HPC RIA [Ref 25].

Table 4-1 Gaseous Dispersion and Deposition Parameters

Parameter	Value
Distance from reference stack (m)	450
Bearing from reference stack (°)	15-45
Physical stack height (m)	70
Height of tallest building affecting stack releases (m)	60
Effective stack height (m)	20
Meteorological data	Site specific (SZC centred windrose)
Roughness length (m)[5]	0.3
Deposition velocity (m/s)	5.00E-3 (tritium) 0 (noble gases and C-14) 1.00E-2 (iodine) 1.00E-3 (particulates)
Washout coefficient (1/s)	1.00E-4 (excluding gases, which were 0)
Deposition rates (Bq/m^2/s)	1

4.2 Habitat 2 (Marine Habitat)

32. The dispersion and accumulation of radioactivity in Habitat 2 (unfiltered seawater and seabed sediment from the local marine compartment) from continuous release of radionuclides in aqueous discharges were

[4] The Met data used in the 2015 assessment has not been updated, as the ten year average is unlikely to be significantly affected by altering three years' worth of data.

[5] Surface roughness considers the effects of attributes such as landscape, buildings and vegetation on wind speed. The roughness length is the height above the ground at which the wind speed, due to building and vegetation etc., drops to zero. The roughness length value of 0.3 m used corresponds to generic agricultural land, which represents the predominant land use of the area around the Sizewell C site.

modelled using the DORIS module of PC-CREAM 08 [Ref 27]. DORIS calculates the time-dependent activity concentration of aqueous radionuclide discharges in the local and regional marine compartments.

33. The local marine compartment is modelled as a single well-mixed body of water and associated sediment, extending 4 km out to sea and 5km along the coastline either side of the proposed SZC site (i.e. 10 km in total). The local compartment is contained within the larger regional compartment with which it interacts and exchanges water and suspended sediment [Ref 27].

34. The focus of protection in biota dose assessments is on the population, not an individual or sub-set of individuals within that population [Ref 5]. The DORIS module of PC-CREAM 08 [Ref 27] predicts concentrations of radioactivity in environmental media (i.e. water and sediment) that are averaged across the local marine compartment. These environmental concentrations have then been used to predict the dose rates to NHB.

35. Aqueous discharges from the neighbouring SZB facility were considered to be released into the same marine compartment as SZC discharges.

36. The DORIS model parameters and values used to model the dispersion of aqueous radionuclides discharged into the marine environment from SZC are provided in Table 4-2 below.

Table 4-2 Marine Dispersion Parameters

Parameter	Local compartment	Regional compartment
Volume (m^3)	4.00E+08	4.50E+11
Depth (m)	1.00E+01	3.10E+01
Coastline length (m)	1.00E+04	-
Volumetric exchange rate (m^3/y)	1.10E+10	-
Suspended sediment load (t/m^3)	8.00E-05	6.00E-06
Sedimentation Rate ($t/m^2/y$)	1.00E-04	1.00E-04
Sediment density (t/m^3)	2.60E+00	2.60E+00
Diffusion rate (m^2/y)	3.15E-02	3.15E-02

37. All parameters in are the PC CREAM 08 default values, except for the volume of the local compartment, which has been increased from 3.00E+08 m^3 to 4.00E+08 m^3 to ensure that the discharge point (roughly 3.5 km from the coast) is within the local compartment. The default volumetric exchange rate corresponds to a local compartment volume of 3.00E+8 m^3. This has been retained as a new volumetric exchange rate cannot be derived without hydrographical data relevant to the area [Ref 31]. A local compartment of 4.00E+8m^3 would have a higher exchange rate, which would result in lower doses, so it is conservative to retain the default value [Ref 31]. The change in volume is small compared to the volume of the regional compartment, so the impact on the regional compartment is expected to be small.

4.3 Habitat 3 (Coastal Habitat)

38. Given that this habitat is considered to comprise terrestrial and marine habitats, analogous to Habitats 1 and 2 above, and to be inhabited by the same organisms that occupy Habitats 1 and 2 above, a separate assessment was not considered necessary. Instead, the environmental concentration data calculated for Habitats 1 and 2 using supporting models in PC-CREAM 08 were adopted for Habitat 3.

4.4 Habitats 4 and 5 (Scrape and Marshland Habitats)

39. The concentration of radionuclides in the scrape (Minsmere Nature Reserve, within the Minsmere-Walberswick Heaths and Marshes SPA) and marshland (the Minsmere-Walberswick Heaths and Marshes SSSI, SPA and Ramsar) from the deposition of gaseous releases was calculated using the IAEA SRS-19 model [Ref 32]. The SRS-19 model considers both direct deposition of radionuclides into a small lake (< 400 km^2) and indirect contributions from radionuclides deposited into its watershed through runoff, surface soil erosion and groundwater seepage. It is assumed that the watershed is 100 times the lake surface area, and that 2% of radionuclides deposited on to the watershed reach the scrape [Ref 32] [Ref 31]. As scrape and marshland contain freshwater bodies, this is an appropriate model to use. The parameters used to define the scrape and marshland are given in Table 4-3.

40. The deposition rates from radionuclides discharged into the atmosphere were modelled within the PLUME module of PC-CREAM 08 in the manner described for Habitat 1. The calculated deposition rates were used to derive the radionuclide discharge rates into the scrape (due to direct deposition and the contributions from the surrounding catchment) in accordance with the SRS-19 methodology for small lakes [Ref 32].

41. The parameters used for this assessment are presented in Table 4-3. The environmental concentrations data calculated are presented in Appendix C.

Table 4-3 Parameters for Freshwater Habitats (Scrape and Marshland)

Parameter	Value
Generic PLUME Model Parameters	
Distance from reference stack (m)	2500
Bearing from reference stack (°)	345
Effective stack height (m)	20
Meteorological data	Site specific (SZC centred windrose)
Roughness length (m)	0.3
Deposition velocity (m/s)	5.00E-3 (tritium) 0 (noble gases and C-14) 1.00E-2 (iodine) 1.00E-3 (particulates)
Washout coefficient (1/s)	1.00E-04 (excluding gases, which were 0)
Scrape Parameters [Ref 16]	
Scrape surface area (m^2)	40450
Scrape depth (m)	2
Scrape volume (m^3)	80900
Inflow (m^3/s)	0
Outflow (m^3/s)	0
Marshland Parameters [Ref 16]	
Marshland surface area (m^2)	1861554
Marshland depth (m)	0.1
Marshland volume (m^3)	186155
Inflow (m^3/s)	0
Outflow (m^3/s)	0

5 ASSESSMENT APPROACH

42. The assessment of radiological impacts due to discharges from SZC and the neighbouring SZB facility on NHB was undertaken using the ERICA Integrated Approach, which comprises the ERICA tool and the associated FREDERICA database [Ref 33] [Ref 34]. The ERICA approach was the product of the Framework for the Assessment of Environmental Impact (FASSET) (2004) and ERICA (2007) research projects commissioned by the European Commission (EC) (the ERICA project was effectively a continuation and consolidation of the FASSET project) and provides a comprehensive methodology for assessing the ecological effects of ionising radiation on NHB and ecosystems [Ref 33]. It is an internationally recognised tool for NHB radiological assessments. The Environment Agency's Research & Development (R&D)128 methodology [Ref 35] was used to assess the impacts of releases of noble gases, which are not currently included in the ERICA approach.

5.1 ERICA Integrated Approach

43. Version 1.2 of the ERICA tool was released in November 2014, and was further updated to Version 1.2.1 in February 2016 [Ref 36]. A subsequent version (Version 1.3.1.49) was released in June 2019. Version 1.2

introduced a new database with a new index list (new reference organisms) based on the IAEA wildlife transfer database [Ref 17]. There were a number of improvements in Version 1.2 including rationalisation of reference organisms, modification to occupancy factors and improvements to the CRs [Ref 36]. Version 1.2.1 included further amendments to the CRs for some radionuclides. Although Version 1.2.1 was used for this assessment, the terrestrial assessment was repeated using Version 1.3.1.49 and the results were found to be unchanged[6].

44. The ERICA tool is a multi-tiered software programme with supporting databases that allows the assessment of absorbed dose rates to a set of reference organisms that are representative of those commonly found in terrestrial, freshwater and marine ecosystems, for a range of radionuclides. The ERICA reference organisms incorporate the ICRP's RAPs as well as some species protected under European legislation [Ref 37].

45. The ERICA tool calculates dose rates to organisms through the application of dose conversion coefficients (DCCs) to the concentrations of radionuclides in environmental media or in biota. DCCs are defined as the absorbed dose rate (µGy/h) per unit activity concentration in an organism (Bq/kg fresh weight (fw)) or environmental media (Bq/kg or Bq/l media fw). A range of DCCs for both internal and external exposures have been calculated for reference organisms-radionuclides-radiation type combinations and are contained in databases embedded within the ERICA tool. Details of the derivation of the DCCs can be found in [Ref 33] and [Ref 38].

46. External dose rates are calculated through the application of external DCCs to environmental media concentrations of radionuclides; occupancy factors are also applied to account for the fraction of time an organism spends in different locations/compartments of the reference ecosystem (for instance, the amount of time a rat spends on-soil or in-soil). External dose rates are calculated on the basis of a simplified ellipsoid geometry which considers only the main body of organisms (extremities such as legs are not accounted for) [Ref 33]. Work to demonstrate that the simplified geometry approach is fit for purpose in providing a pessimistic dose estimate is currently ongoing within the IAEA Modelling and Data for Radiological Impact Assessments programme. The Initial findings of which suggest that the ellipsoidal approach is indeed fit for purpose [Ref 37].

47. Dose rates from internally incorporated radionuclides are assessed in two stages [Ref 39]:

    - Stage 1 involves the estimation of the activity concentrations in biota through the application of equilibrium CRs to corresponding media activity concentrations (soil or air for terrestrial ecosystems and water for aquatic ecosystems). CRs assume equilibrium conditions and a uniform distribution of the radionuclide within the organism (i.e. with no accumulation of radionuclides within individual tissues). The ERICA tool comprises a database containing default CR values for key elements and reference organisms derived from review of published data, augmented with data acquired through the use of analogues, taxonomic considerations or modelled data, or a combination of approaches [Ref 33] and [Ref 34].
    - Stage 2 involves the application of internal DCCs to the radionuclide concentrations in organisms (from Stage 1 above) to calculate the dose due to internal irradiation of exposed organisms.

48. Radiation weighting factors are applied to take account of the differing biological effectiveness of different types of ionising radiation. The default radiation weighting factors for alpha of 10, low energy beta of 3

[6] Version 1.3.1.49 was released in June 2019 while this report was being prepared. The updates mainly affected the user interface, but one update had the potential to affect dose rates in the terrestrial ecosystem. The terrestrial assessment was repeated using version 1.3.1.49 of ERICA, and it was found that the results were unchanged.

and gamma/beta of 1 in the ERICA tool [Ref 33] [Ref 34] were used for the NHB assessments. The result is expressed as a 'weighted absorbed dose' in Gy/h.

49. Total dose rates to the reference organisms are calculated as the sum of the weighted internal and external dose rates.

50. The ERICA tool also contains a database of distribution coefficients (Kd) for all default radionuclides, used to estimate activity concentrations in sediment from water concentrations and vice versa (the Kd is the ratio of activity concentration per unit mass of sediment to the activity concentration per unit volume of water) [Ref 33] [Ref 34].

51. The ERICA assessment tool is organised in three tiers where satisfying certain criteria in Tiers 1 and 2 allows the user to exit the assessment process while being confident that the effects on biota are low or negligible, and that the situation requires no further action. Where the effects are not shown to be negligible, the assessment should continue to the next Tier (Tier 2 and 3, respectively). Further details on the different Tiers is provided below:

- Tier 1 of the ERICA tool enables a simple and pessimistic screening assessment to be carried out. This tier incorporates Environmental Media Concentration Limits (EMCLs) for each radionuclide-reference organism combination, derived on the basis of a screening dose rate of 10 µGy/h. Input media concentrations (e.g. activity concentration in sediment or unfiltered water) are compared with the EMCL for the most limiting reference organism for each radionuclide to calculate the RQ[7]. If the sum of RQ values is less than one, there is a very low probability that the absorbed dose rate to any organism would exceed the screening dose rate and the assessment can be concluded at this stage [Ref 33].
- Tier 2 is also a screening tier however it is more interactive and affords greater flexibility in the choice of model parameters. It allows the modification of default model parameters (including Kd, CR, occupancy factors and radiation weighting factors) and the addition of non-default radionuclides and organisms (with user-defined geometries and attributes). In Tier 2, the estimated total weighted absorbed dose rates for each reference organism assessed are compared directly with the selected screening dose rate to produce a RQ for the organism [Ref 39]. Tier 2 also facilitates the inclusion of uncertainty factors (UF) to account for uncertainties in the dose rate calculations and estimate the probability of exceeding the screening dose rates. The UF is multiplied by the RQ to obtain a 'conservative RQ' value. A UF of 3, (corresponding to the 95th percentile values) [Ref 34] was adopted for the SZC NHB assessments.
- Tier 3 facilitates the undertaking of probabilistic risk assessment in which uncertainties associated with the results may be estimated using sensitivity analysis. It allows access to the FREDERICA database and the use of up-to-date scientific literature on the biological effects of exposure to ionising radiation in a number of different species. Together, these allow the user to estimate the probability (or incidence) and magnitude (or severity) of the environmental impacts likely to occur [Ref 33].

52. The impacts of aqueous and gaseous radioactive discharges from SZC on NHB were assessed at Tier 2 of the ERICA tool. No further assessment was required at Tier 3 level due to the results satisfying the criteria in Tier 2 providing confidence that the effects on biota are low or negligible. Details of the ERICA parameters used in the SZC assessment are provided in Appendix E.

[7] The ratio of the predicted absorbed dose rate to the screening dose rate.

5.2 R&D 128 methodology

53. The Environment Agency's R&D 128 methodology was developed for the assessment of radiological impacts on Natura 2000 sites for compliance with the EC Habitats Directive in England and Wales [Ref 35]. The methodology is accompanied by an Excel spreadsheet-based model which uses a similar approach to that of the ERICA tool, but considers a smaller range of organisms and radionuclides. An updated version of the terrestrial ecosystem spreadsheet was issued in 2014, which included additional isotopes Kr-88, Xe-131m and Xe-133 isotopes and introduced additional organisms [Ref 40]. The R&D 128 methodology also provides guidance on the estimation of CR values for a given radionuclide-organism combination, and includes additional organisms of conservation significance in the UK that are not included in the ERICA default reference organisms [Ref 35]. Such organisms can be assessed in ERICA using the data presented in the R&D 128 documentation.

54. The assessment of impacts on NHB due to releases of noble gases from SZC, which constitute the largest component of predicted gaseous releases from the facility in terms of activity released, is not possible using the ERICA tool. Such assessments can however be carried out using the R&D 128 methodology (which incorporates representative noble gases) and the R&D 128 approach was used to calculate the dose rates to organisms occupying Habitat 1 arising from the discharge of noble gases from SZC.

55. The R&D 128 methodology does not allow for additional organisms to be added and, hence, the standard list of organisms was used to calculate dose from noble gases. The R&D 128 organisms were not themselves matched to the ERICA default reference organisms, described below in Section 6, as the older R&D 128 system is not directly consistent with ERICA. There are nonetheless similarities between the sets of organisms in the two models. For example, a bee is used in R&D 128, and the reference flying insect in ERICA is based on a bee. Whilst some organisms are broadly consistent, there are notable differences in the representation of others. The calculation of dose to a tree within R&D 128 focusses on the root, whereas in ERICA the focus is on the trunk. There are also some organisms within ERICA that are not included within R&D 128, such as an amphibian.

56. With the differences in the organisms between the two methodologies, species have not been matched, and as such dose rates are presented separately for ERICA derived values and those calculated using R&D 128. With the publication of the new Ar-Kr-Xe dose calculator [Ref 40], dose from exposure to selected noble gases can now be evaluated for the ERICA default organisms based on a derived Excel-based R&D 128 methodology. Hence, dose rate calculations could all be updated to a common framework. However, due to the very low doses predicted, i.e. NHB doses well below national / international thresholds and screening values, there is no technical basis to drive further work.

57. The R&D 128 methodology recognises two representative noble gases, Ar-41 and Kr-85, which are included in the assessment spreadsheet tool. The spreadsheet does not allow the inclusion of additional radionuclides. Ar-41 - which has higher gamma and beta energies than Kr-85 and the isotopes of xenon - was therefore used as a surrogate for the isotopes of xenon (Xe-131m, Xe-133 and Xe-135) [Ref 35][8], which provides a pessimistic assessment.

6 REFERENCE ORGANISMS

58. Radiological impact assessments that employ tools and approaches such as R&D 128, ERICA and the ICRP RAPs methodology aim to determine whether there could be ecological harm, based on a range of organism types and associated ecology within a generic habitat type. The default organisms within these

[8] This is consistent with the approach used for the HPC NHB assessments, and with the Environment Agency's Initial Radiological Assessment Tool which uses Ar-41 as surrogate for Xe-133.

assessment tools and approaches have been selected to encompass the types of plant and animal that would be expected to be present in terrestrial, freshwater and marine ecosystems throughout temperate climates. The ERICA reference organisms were also selected to enable all protected species within Europe to be addressed [Ref 33].

59. The approach used in the demonstration of environmental protection in terms of NHB radiological protection is akin to comparison of chemical concentrations relative to environmental quality standards. This differs from an Ecological Impact Assessment that may focus not just on a species, but a population or even individuals within a sub-population. Such detail is not normally considered unless there is clear reason to believe that there may be environmental damage. However, based on initial results, more detailed assessments can then be undertaken if required.

60. On the basis of the calculated dose rates across the different habitats and organisms, no impact on populations of NHB from authorised discharges from SZC is likely as a result of exposure to radiation. Furthermore, the dose rates were calculated on the basis of maximum radioactivity concentrations, consistent with a cautious assumption that discharges occur at permit limits.

61. The plant and animal species occupying the habitats around the SZC Site, identified in the SZC Stage 1 Report (Table 4.2.2 and 4.2.4, and Paragraph 4.2.8) [Ref 8] have been compared to ERICA default reference organisms and two additional organisms (bat and badger) were included in the SZC NHB assessment. Further detailed comparisons of local species and the ERICA default organisms have been carried out on behalf of SZC Co. [Ref 16].

62. The majority of species identified in the Stage 1 report are broadly similar to ERICA reference organisms and the additional organisms. It is however noted that there are disparities in the physical dimensions of some local species compared to the ERICA representative organisms. For instance, a wide variety of bird species were reported to inhabit the designated sites close to SZC including species such as the bearded tit (Panurus biarmicus), woodlark (Lullula arborea) and black redstart (Phoenicurus ochruros), which are smaller than the equivalent ERICA reference organism (duck).

63. The ERICA default bird size, evaluated in the assessment, is based on the ICRP reference duck with a mass of 1.26 kg and dimensions of 30 cm x 10 cm x 8 cm. In terms of predicted dose, the implication of size variation is small with variation in ellipsoid dimensions having only a limited effect (up to a factor of 2 for a mass range of 1 g to 100 kg) on dose rate calculations [Ref 43]. For organisms lighter than 1 g (i.e. dimensions in the order of millilitres), geometry becomes more important. The variation in dose rate across different bird species, attributable to differences in bird size, is therefore trivial.

64. The ERICA default reference organisms for marine, terrestrial and freshwater ecosystems were adopted for the assessment of impacts to NHB. Non-default organisms including bats (e.g. Pipistrellus pipistrellus and Barbastella barbastellus), badgers (Meles meles), harbour porpoise (Phocoena phocoena) and lamprey (Petromyzontiformes) have been identified as present and of conservation significance for the environment surrounding the proposed SZC site [Ref 16].

65. Bats and badgers are not represented by the default ERICA reference organisms, which exclude flying mammals[9] and large burrowing mammals. They were therefore added to, and modelled explicitly within, ERICA.

[9] Flying organisms are conservatively represented within ERICA as having an 'on-soil' occupancy in the terrestrial environment. The small mammal default reference organism is based on a rat and has occupancy within the soil column. Use of the small mammal reference organism would not, therefore, be representative of the occupancy habits of bats within an ERICA assessment context.

66. The Harbour Porpoise was not explicitly considered. The default ERICA organism list for the marine environment includes a marine mammal. The default dimensions for a marine mammal in ERICA are 180 cm x 44 cm x 44 cm. The length of the default marine mammal is broadly consistent with that of a Harbour Porpoise, noting that variation in dimensions of larger mammals has a trivial impact on dose calculations. The marine mammal reference organism is therefore considered to be sufficiently representative of the Harbour Porpoise. Total dose rate from SZC discharges for the marine mammal was calculated as 0.0040 µGy/h, which is several orders of magnitude below the assessment threshold.

67. The lamprey was also not explicitly modelled. However, both the marine and scrape habitats included benthic and pelagic fish. Benthic fish are the maximising case due to exposure to radioactivity in the sediment. Dose rates for fish in the marine environment were assessed to be 0.37 µGy/h (benthic) and 0.0019 µGy/h (pelagic). In the scrape environment dose rates were 0.015 µGy/h (benthic) and 0.0018 µGy/h (pelagic). Whilst lamprey may vary in size from the default fish reference organisms, the difference in dose rate attributable to size differences are likely to be trivial.

68. The radioecology parameters (CR) for badger and bat were based on the ERICA default values for mammals of comparable respective size. Bats are assumed to reside 'on soil' all the time (which represents a pessimistic basis for an organism that spends most of their time flying or roosting at height above ground, allowing external exposure to radionuclides deposited on soil), whilst badgers are assumed to spend half the time 'in soil' and the other half 'on soil'.

69. Data on the physical attributes (weight and geometry) of non-default organisms were sourced from publications by relevant conservation organisations (e.g. ARKive, Bat Conservation Trust and Badger Trust). The ERICA approach for modelling dose-rates to organisms 'in-soil' is restricted to an upper mass range of 6.6 kg. To assess the total dose rate to badger (13 kg) due to in-soil occupancy, the upper range value (6.6 kg) was applied. The ERICA documentation indicates that the external dose rates to organisms with masses above the allowed upper mass limit are lower than the exposure specified at the limit. The internal dose rate to an in-soil organism with a mass of 10 kg is estimated to be <25% (for exposure to a 1 MeV photon) and <2% (for alpha/beta) higher than the dose rate to an organism at the upper mass limit of 6.6 kg. However, H-3 and C-14 (both weak beta emitters) contribute >99% of the internal dose rate to in-soil badger; the net effect of the difference in mass between the badger and the upper limit for in soil organisms is therefore considered to be insignificant and no correction factors were applied.

70. The full list of organisms assessed (comprising the default ERICA reference organisms and the additional organisms) and their attributes are reproduced in Appendix E. The reference organisms used to represent local species are also identified in Appendix F.

Occupancy Habits

71. The occupancy habits of reference organisms within ERICA are described in terms of the proportion of time reference organisms spend in different compartments of the relevant ecosystems [Ref 34] as explained in the following paragraphs.

72. For aquatic (marine and freshwater) ecosystems, the occupancy options include:

- Water-surface – refers to time spent by an organism such as a duck on the water surface.
- Water - refers to time spent by organisms such as pelagic fish (e.g. a salmon or trout) swimming through the water column.
- Sediment-surface - refers to time spent by organisms close to the bottom of the water column (e.g. a benthic fish such as flounder or carp) or on the surface of the sediment (such as some macrophytes).
- Sediment - refers to time spent by organisms (e.g. marine polychaete worms) buried in the sediment.

73. The occupancy options for terrestrial ecosystems are:

- On-soil - refers to time spent by organisms on the surface of the soil, for instance when a mammal such as a mouse is foraging for food.
- In-soil - refers to time spent by an organism within the soil matrix (e.g. organisms like earthworms or a burrowing mammal) when they are buried in the soil.
- In-air - refers to time spent in the air and applies to flying organisms such as birds.

74. Organisms inhabiting coastal habitats (e.g. wading birds) are assumed to spend equal amounts of time in the terrestrial and marine environments.

75. Details of the occupancy habits of the reference organisms on and around the SZC site are reproduced in Appendix E.

7 RESULTS AND DISCUSSION

76. The dose rates to organisms occupying the five habitats identified in the preceding sections were assessed at Tier 2 of the ERICA approach due to the need to consider non-default organisms. The assessment was carried out for all the default marine, terrestrial and freshwater organisms within ERICA that are applicable to a UK context[10]. Dose rates to the non-default organisms identified earlier have also been assessed.

77. The Environment Agency, together with Natural England and the Countryside Council for Wales (now part of Natural Resources Wales) have concluded that 40 µGy/h is the threshold below which adverse effects on the integrity of protected sites (SACs and SPAs) are not anticipated to occur [Ref 4] [Ref 35]. This criterion has been used as the current Environment Agency threshold dose rate against which the assessed dose rates were compared. The results are also compared with the ERICA recommended screening dose rate of 10 µGy/h.

7.1 Dose Rates due to Sizewell C Discharges

7.1.1 Habitat 1

78. The dose rates to terrestrial organisms residing within Habitat 1 from exposure to gaseous discharges from the SZC facility that deposit to ground were assessed based on the pessimistic assumption that the organisms inhabit the location of maximum offsite air concentration and deposition rates, 450 m and 15-45° from the reference stack. Large and small burrowing mammals (large and small-burrowing) received the highest dose rates of 0.005 µGy/h calculated using the ERICA tool; these dose rates are around four orders of magnitude below the current Environment Agency screening dose rate of 40 µGy/h and around three orders of magnitude below the ERICA recommended screening dose rate of 10 µGy/h. The corresponding RQ value is 0.00012. Thus, the probability that the estimated dose rate these organisms receive will exceed the screening dose rate is extremely low and any consequent risk to the organisms is considered trivial. The dose rate to the worst affected terrestrial organism (caterpillar) from exposure to noble gases, calculated using the R&D 128 spreadsheet, was 0.0018 µGy/h.

79. Table 7-1 below presents a summary of the assessed dose rates and the corresponding RQs for terrestrial organisms.

[10] There are no marine reptile species associated with the coastal waters of the UK and the default reference organism 'reptile' was therefore excluded.

Table 7-1 Dose Rates to Habitat 1 (Terrestrial) Organisms due to Gaseous Discharges from Sizewell C at Proposed Limits

Organism	Total Dose Rate per organism (µGy/h)	Risk Quotient (expected value) (unitless)
Amphibian	4.8E-03	1.2E-04
Annelid	2.0E-03	4.9E-05
Arthropod - detritivorous	2.0E-03	4.9E-05
Bat	4.9E-03	1.2E-04
Bird	5.0E-03	1.2E-04
Flying insects	1.9E-03	4.8E-05
Grasses & Herbs	3.4E-03	8.5E-05
Lichen & Bryophytes	3.4E-03	8.6E-05
Mammal - large	5.0E-03	1.2E-04
Mammal - small-burrowing	5.0E-03	1.2E-04
Mollusc - gastropod	2.0E-03	4.9E-05
Reptile	5.0E-03	1.2E-04
Shrub	3.4E-03	8.5E-05
Tree	4.9E-03	1.2E-04
Badger	4.9E-03	1.2E-04

80. C-14 accounts for between 70% and 88% of internal dose rates, which in turn constitutes over 99% of the total dose rates to terrestrial organisms. Co-60 accounts for up to 54% of the external dose rates. A breakdown of dose rates by radionuclides is provided in Appendix D, Table D-10.

7.1.2 Habitat 2

81. The dose rates to marine organisms residing within Habitat 2 from exposure to aqueous discharges from the SZC facility were assessed based on the assumption that the organisms inhabit the local marine compartment. The worst affected organism was the polychaete worm with a dose rate of 0.80 µGy/h. This dose rate is more than an order of magnitude below the current Environment Agency screening dose rate of 40 µGy/h and the ERICA recommended screening dose rate of 10 µGy/h. The corresponding RQ value is 0.020, thus the probability that the estimated dose rate to this organism will exceed the screening dose rate is very low and any consequent risk to the organism is trivial.

82. Table 7-2 below presents a summary of the assessed dose rates and the corresponding RQs for marine organisms.

Table 7-2 Dose Rates to Habitat 2 (Marine) Organisms due to Aqueous Discharges from Sizewell C at Proposed Limits

Organism	Total Dose Rate per organism (µGy/h)	Risk Quotient (expected value) (unitless)
Bird	2.1E-03	5.2E-05
Benthic fish	3.7E-01	9.2E-03
Crustacean	3.7E-01	9.2E-03
Macroalgae	4.0E-01	1.0E-02
Mammal	4.0E-03	1.0E-04
Mollusc - bivalve	3.9E-01	9.9E-03
Pelagic fish	1.9E-03	4.8E-05
Phytoplankton	6.3E-04	1.6E-05
Polychaete worm	8.0E-01	2.0E-02
Sea anemones & True coral	4.0E-01	9.9E-03
Vascular plant	3.9E-01	9.8E-03
Zooplankton	5.4E-03	1.3E-04

83. The three dominant radionuclides accounting for the highest proportions of dose rates to marine organisms are C-14 and Ag-110m for internal dose rates and Co-60 for external dose rates. The contribution of external and internal dose rates to the total dose rates is variable, with external dose rates dominating the exposure for some organisms and vice versa for internal dose rates. A breakdown of dose rates by radionuclides is provided in Appendix D.

7.1.3 Habitat 3

84. Habitat 3 is a coastal environment considered to straddle Habitats 1 and 2 (terrestrial and marine) and dose rates calculated for default terrestrial and marine reference organisms in Habitats 1 and 2 are therefore considered bounding for this case, with organisms being assumed to reside permanently within their natural habitat (i.e. either the terrestrial or marine habitats). The dose rates to coastal organisms are therefore considered to be the same as those presented in Table 7-1 and Table 7-2 above. However, for some coastal bird species, such as Eurasian teal and Gadwall, occupancy of both marine and terrestrial habitats will occur. For such birds it is assumed that equal time is spent in each of the two habitats.

85. Table 7-3 below presents the dose rates experienced by bird species inhabiting the coastal environment. The dose rate (assuming a 50/50 occupancy in terrestrial and marine habitats) is calculated to be 0.0035 µGy/h, which is slightly lower than that for birds occupying only the terrestrial environment. Dose rates to coastal birds are around four orders of magnitude below the current Environment Agency screening dose rate of 40 µGy/h and more than three orders of magnitude below the ERICA recommended screening dose rate of 10 µGy/h. The corresponding RQ value is <0.0001 (i.e. the probability that the estimated dose rate to this organism will exceed the screening dose rate is extremely low and any consequent risk to the organism is considered trivial).

Table 7-3 Dose Rates to Habitat 3 (Coastal) Organisms due to Aqueous and Gaseous Discharges from Sizewell C at Proposed Limits

Coastal Habitat	Organism	Total Dose Rate per organism (µGy/h)	Risk Quotient (expected value) (unitless)
Terrestrial compartment	Bird	5.0E-03	1.2E-04
Marine compartment	Bird	2.1E-03	5.2E-05
Both compartments (assuming 50/50 occupancy)	Bird	3.5E-03	8.8E-05

86. A breakdown of dose rates by radionuclides is not provided separately for coastal organisms – however, this can be inferred from the breakdown provided for terrestrial (Habitat 1) and marine (Habitat 2) organisms in Appendix D.

7.1.4 Habitat 4

87. The dose rate to the worst affected organism residing within Habitat 4 (freshwater scrape) is 0.032 µGy/h to insect larvae, arising from exposure to gaseous radionuclides deposited onto the scrape and its catchment. This dose rate is more than three orders of magnitude below the current Environment Agency screening dose rate of 40 µGy/h and more than two orders of magnitude below the ERICA recommended screening dose rate of 10 µGy/h. The corresponding RQ value is 0.0008, thus the probability that the estimated dose rate to this organism will exceed the screening dose rate is very low and any consequent risk to the organism is trivial. Table 7-4 below presents a summary of the assessed dose rates and the corresponding RQs for freshwater scrape organisms.

Table 7-4 Dose Rates to Habitat 4 (Freshwater Scrape) Organisms due to Gaseous Discharges from Sizewell C at Proposed Limits

Organism	Total Dose Rate per organism (µGy/h)	Risk Quotient (expected value) (unitless)
Amphibian	1.8E-03	4.5E-05
Benthic fish	1.5E-02	3.6E-04
Bird	1.8E-03	4.4E-05
Crustacean	1.7E-02	4.2E-04
Insect larvae	3.2E-02	8.0E-04
Mammal	1.8E-03	4.4E-05
Mollusc - bivalve	1.6E-02	3.9E-04
Mollusc - gastropod	1.6E-02	4.0E-04
Pelagic fish	1.8E-03	4.5E-05
Phytoplankton	1.6E-03	4.1E-05
Reptile	1.4E-02	3.6E-04
Vascular plant	1.7E-02	4.2E-04
Zooplankton	1.6E-03	4.1E-05

88. H-3 accounts for between 89% and 100% of internal dose rates, while Co-60 dominates external dose rates accounting for between 41% and 52% to the total dose rates to the scrape organisms. The

contribution of external and internal dose rates to the total dose rates is variable, with external dose rates dominating the exposure for some organisms and vice versa for others. A breakdown of dose rates by radionuclides is provided in Appendix D Table D-12.

7.1.5 Habitat 5

89. The marshland habitat was assessed as a shallow scrape adopting the same approach used for the freshwater scrape. The dose rate to the worst affected organism within this habitat is 0.64 µGy/h to insect larvae, arising from exposure to gaseous radionuclides deposited onto the scrape and its catchment. This dose rate is more than an order of magnitude below the current Environment Agency screening dose rate of 40 µGy/h and the ERICA recommended screening dose rate of 10 µGy/h. The corresponding RQ value is 0.016; thus, the probability that the estimated dose rate to this organism will exceed the screening dose rate is very low and any consequent risk to the organism is trivial.

90. Table 7-5 below presents a summary of the assessed dose rates and the corresponding RQs for freshwater scrape organisms.

Table 7-5 Dose Rates to Habitat 5 (Marshland) Organisms due to Gaseous Discharges from Sizewell C at Proposed Limits

Organism	Total Dose Rate per organism (µGy/h)	Risk Quotient (expected value) (unitless)
Amphibian	3.6E-02	9.0E-04
Benthic fish	2.9E-01	7.3E-03
Bird	3.5E-02	8.8E-04
Crustacean	3.4E-01	8.4E-03
Insect larvae	6.4E-01	1.6E-02
Mammal	3.5E-02	8.9E-04
Mollusc - bivalve	3.1E-01	7.8E-03
Mollusc - gastropod	3.2E-01	8.0E-03
Pelagic fish	3.6E-02	9.0E-04
Phytoplankton	3.3E-02	8.2E-04
Reptile	2.9E-01	7.2E-03
Vascular plant	3.4E-01	8.4E-03
Zooplankton	3.3E-02	8.2E-04

91. H-3 accounts for between 89% and 100% of internal dose rates, while Co-60 dominates external dose rates accounting for between 41% and 52% of the total dose rates to the scrape organisms. The contribution of external and internal dose rates to the total dose rates is variable, with external dose rates dominating the exposure for some organisms and vice versa for internal dose rates. A breakdown of dose rates by radionuclides is provided in Appendix D Table D-13.

7.2 Dose Rates due to the Combined Discharges from Sizewell B and C facilities

92. The Environment Agency has carried out a study assessing the impact of radioactive waste discharges on Natura 2000[11] sites in England and Wales [Ref 4]. The assessments calculated dose rates to organisms in coastal, freshwater and terrestrial environments due to the combined impact of all discharges authorised

[11] Natura 2000 is made up of sites designated as SACs and SPAs.

under the Radioactive Substances Act 1993 (now superseded by the EPR16 in England and Wales), that could have an impact on a Natura 2000 site. The assessment was based on the cautious assumption that all discharges occur at permit limits.

93. It should be noted that the Environment Agency Natura 2000 study results are based on a precursor methodology to ERICA, and are not consistent with the ERICA assessment methods. In addition, at the time of the Environment Agency Natura 2000 site assessment, the Outer Thames Estuary was not designated as a SPA.

94. Table 7-6 below presents the Environment Agency calculated dose rates to the worst affected organisms inhabiting the designated sites close to the SZC site (Minsmere to Walberswick SPA, Minsmere to Walberswick Heaths and Marshes SAC, and Sandlings SPA) [Ref 4]. The Environment Agency results show the total dose rate to biota at the Minsmere to Walberswick SPA based on existing site permits (SZA and SZB) at the time of the study was 9.3 µGy/h and that the highest dose rate at the sites of interest was for the Sandlings Heath SPA of 16 µGy/h. These values are pessimistic and are based on discharges at operational authorisation limits. All but two of these values are below the recommended screening value in ERICA of 10 µGy/h. Nonetheless, all the values are still well below the current Environment Agency threshold of 40 µGy/h, the dose rate below which the Environment Agency and relevant conservation bodies have agreed that there will be no adverse effect on the integrity of a conservation site.

Table 7-6 Dose Rates to the worst affected Organisms Residing in Natura 2000 Sites near Sizewell C (Taken from the Environment Agency Study [Ref 4])

Environment Agency Site Code	Site name	Priority[12]	Total dose rate (µGy/h)[13]	Coastal – Local comp. (µGy/h)	Coastal– Regional comp. (µGy/h)	Total coastal (µGy/h)	Fresh-water (µGy/h)	Max water dose rate (µGy/h)	Terrestrial dose rate (µGy/h)
A28	Minsmere to Walberswick SPA	M	9.3	1.3E-01	1.3E-02	1.4E-01	3.1E-01	3.1E-01	9.0
A29	Minsmere to Walberswick Heaths and Marshes SAC	M	9.1	1.3E-01	1.3E-02	1.4E-01	0.0	1.4E-01	9.0
A46	Sandlings pSPA	L	16	1.5	1.3E-02	1.5	3.6	3.6	12
A35	Orfordness – Shingle Street cSAC	L	1.5	1.5	1.3E-02	1.5	0.0	1.5	0.0
A02	Alde-Ore Estuary SPA	M	9.3	1.3E-01	1.3E-02	1.4E-01	3.1E-01	3.1E-01	9.0
A03	Alde, Ore and Butley Estuaries cSAC	M	12	1.3E-01	1.3E-02	1.4E-01	0.0	1.4E-01	12

[12] Allot et al. (2009) [4] categorised Natura 2000 sites as either high, medium or low priority based on the sites' value to conservation. Sites considered here were either medium (M) or low (L) priority.
[13] The Environment Agency calculate the total dose rate as the sum of the terrestrial dose rate and the maximum water dose rate (where the water dose rate is the sum of the freshwater and coastal water dose rates, inclusive of local and regional compartments)

95. The results of the current in-combination effects assessment for SZC have been evaluated against the Environment Agency dose rates [Ref 4] discussed above.

96. In-combination effects arising from the combined discharges of aqueous and gaseous radioactive effluent from SZB (at current permitted discharge limits) and SZC (at proposed discharge limits) have been assessed here using the source terms shown in Table 3-1 and Table 3-2.

97. Discharges from the decommissioning of the SZA facility have not been included in the assessment on the basis that the site would have entered the C&M decommissioning phase by the time SZC becomes operational and discharges from the site would be trivial [Ref 24].

98. There is the potential that in-combination impacts at a regional level (particularly on organisms inhabiting the Outer Thames Estuary SPA) could occur due to discharges associated with the accelerated decommissioning programme for the Bradwell nuclear power station. However, as with SZA, the Bradwell site is scheduled to enter the C&M phase before the SZC site becomes operational [Ref 24], so in-combination effects from discharges from Bradwell were not considered.

7.2.1 Habitat 1

99. The dose rate to the worst affected terrestrial organisms (small-burrowing mammal, large mammal, bird and reptile) from the combined discharges of gaseous effluent from the Sizewell Site (SZB and SZC) is calculated to be 0.0069 µGy/h, with a corresponding RQ of 0.00017. This dose rate is nearly four orders of magnitude below the current Environment Agency threshold dose rate of 40 µGy/h and more than three orders of magnitude lower than the ERICA recommended screening dose rate of 10 µGy/h. The dose rate to the worst affected terrestrial organism (caterpillar) from exposure to noble gases, calculated using the R&D 128 spreadsheet, is 0.0033 µGy/h.

100. By comparison, the dose rates to the worst affected terrestrial organisms reported by the Environment Agency from SZA and SZB were 9.0 µGy/h for Minsmere to Walberswick SPA and SAC, and 12 µGy/h for Sandlings SPA. These dose rates are more than three orders of magnitude above the assessed dose rates for the Sizewell Site discharges.

101. Table 7-7 below presents a summary of the assessed dose rates and the corresponding RQs for terrestrial organisms.

Table 7-7 Dose Rates to Habitat 1 (Terrestrial) Organisms due to the Combined Discharges of Gaseous Effluent from Sizewell B and C at Annual Limits

Organism	Total Dose Rate per organism (µGy/h)	Risk Quotient (expected value) (unitless)
Amphibian	6.7E-03	1.7E-04
Annelid	2.7E-03	6.9E-05
Arthropod - detritivorous	2.8E-03	6.9E-05
Bat	6.8E-03	1.7E-04
Bird	6.9E-03	1.7E-04
Flying insects	2.7E-03	6.7E-05
Grasses & Herbs	4.7E-03	1.2E-04
Lichen & Bryophytes	4.8E-03	1.2E-04
Mammal - large	6.9E-03	1.7E-04
Mammal - small-burrowing	6.9E-03	1.7E-04
Mollusc - gastropod	2.7E-03	6.9E-05
Reptile	6.9E-03	1.7E-04
Shrub	4.7E-03	1.2E-04
Tree	6.7E-03	1.7E-04
Badger	6.8E-03	1.7E-04

7.2.2 Habitat 2

102. The dose rate to the worst affected marine organism (polychaete worm) from the combined discharges of aqueous effluent from the Sizewell Site is calculated to be 0.91 µGy/h, with a corresponding RQ of 0.023. This dose rate is more than one order of magnitude below the current Environment Agency threshold dose rate of 40 µGy/h and the ERICA recommended screening dose rate of 10 µGy/h.

103. By comparison, the dose rates to the worst affected organisms inhabiting the local coastal habitats of the Minsmere to Walberswick SPA and SAC, and the Sandlings SPA as reported by the Environment Agency were 0.13 and 1.5 µGy/h respectively. These dose rates fall either side of the dose rates assessed for the combined discharges from the SZB and SZC stations.

104. Table 7-8 below presents a summary of the assessed dose rates and the corresponding RQs for marine organisms.

Table 7-8 Dose Rates to Habitat 2 (Marine) Organisms due to the Combined Discharges of Aqueous Effluent from Sizewell B and C at Annual Limits

Organism	Total Dose Rate per organism (µGy/h)	Risk Quotient (expected value) (unitless)
Bird	3.5E-03	8.8E-05
Benthic fish	4.2E-01	1.1E-02
Crustacean	4.2E-01	1.0E-02
Macroalgae	4.6E-01	1.1E-02
Mammal	5.7E-03	1.4E-04
Mollusc - bivalve	4.5E-01	1.1E-02
Pelagic fish	2.2E-03	5.5E-05
Phytoplankton	7.1E-04	1.8E-05
Polychaete worm	9.1E-01	2.3E-02
Sea anemones & True coral	4.5E-01	1.1E-02
Vascular plant	4.5E-01	1.1E-02
Zooplankton	5.6E-03	1.4E-04

7.2.3 Habitat 3

105. The dose rates to coastal organisms are considered to be the same as those presented in Table 7-7 and Table 7-8, except for the dose rates to coastal birds, which are given in Table 7-9. Table 7-9 shows that the dose rate to the bird from the combined discharges of aqueous effluent from the Sizewell Site is calculated to be 0.0052 µGy/h, with a corresponding RQ of 0.00013. This dose rate is more than three orders of magnitude below the current Environment Agency threshold dose rate of 40 µGy/h and the ERICA recommended screening dose rate of 10 µGy/h. Table 7-7 and Table 7-8 show that the dose rate to the worst affected coastal organism (polychaete worm) from the combined discharges of aqueous effluent from the Sizewell Site is calculated to be 0.91 µGy/h, with a corresponding RQ of 0.023.

106. By comparison, the dose rates to the worst affected organisms inhabiting the local marine compartments of the Minsmere to Walberswick SPA and SAC, and the Sandlings SPA as reported by the Environment Agency were 0.13 and 1.5 µGy/h respectively. These dose rates fall either side of the dose rates assessed for the combined discharges from the SZB and SZC stations. The dose rate to the worst affected organisms inhabiting the terrestrial compartment of the Minsmere to Walberswick SPA and SAC, and the Sandlings SPA, as reported by the Environment Agency were 9.0 and 12 µGy/h. These dose rates are over four orders of magnitude higher than that assessed for the combined discharges from the Sizewell site.

Table 7-9 Dose Rates to Habitat 3 (Coastal) Organisms due to the Combined Discharges of Aqueous and Gaseous Effluent from Sizewell B and C at Annual Limits

Coastal Habitat	Organism	Total Dose Rate per organism (µGy/h)	Risk Quotient (expected value) (unitless)
Terrestrial compartment	Bird	6.9E-03	1.7E-04
Marine compartment	Bird	3.5E-03	8.8E-05
Both compartments (assuming 50/50 occupancy)	Bird	5.2E-03	1.3E-04

7.2.4 Habitat 4

107. The dose rate to the worst affected scrape organism (insect larvae) from the combined discharges of gaseous effluent from the Sizewell Site, deposited onto the scrape and its watershed, is calculated to be 0.13 µGy/h, with a corresponding RQ of 0.0034. This dose rate is more than two orders of magnitude below the current Environment Agency threshold dose rate of 40 µGy/h and approximately two orders of magnitude lower than the ERICA recommended screening dose rate of 10 µGy/h.

108. By comparison, the dose rates to the worst affected organisms inhabiting the local freshwater habitats of the Minsmere to Walberswick SPA, SAC and the Sandlings SPA were 0.31 and 3.6 µGy/h respectively as reported by the Environment Agency. The dose rates for the Sandlings SPA organisms are more than one order of magnitude greater than the worst dose rates due to the combined discharges from the Sizewell Site. The dose rate for the Minsmere to Walberswick SPA and SAC are comparable to those from the combined discharges from the Sizewell Site.

109. Table 7-10 below presents a summary of the assessed dose rates and the corresponding RQs for scrape organisms.

Table 7-10 Dose Rates to Habitat 4 (Scrape) Organisms due to the Combined Discharges of Gaseous Effluent from Sizewell B and C at Annual Limits

Organism	Total Dose Rate per organism (µGy/h)	Risk Quotient (expected value) (unitless)
Amphibian	2.6E-03	6.6E-05
Benthic fish	6.2E-02	1.6E-03
Bird	2.7E-03	6.8E-05
Crustacean	6.9E-02	1.7E-03
Insect larvae	1.3E-01	3.4E-03
Mammal	2.7E-03	6.6E-05
Mollusc - bivalve	6.7E-02	1.7E-03
Mollusc - gastropod	6.8E-02	1.7E-03
Pelagic fish	2.7E-03	6.7E-05
Phytoplankton	2.5E-03	6.2E-05
Reptile	6.1E-02	1.5E-03
Vascular plant	6.8E-02	1.7E-03
Zooplankton	2.5E-03	6.3E-05

7.2.5 Habitat 5

110. The dose rate to the worst affected marshland organism (insect larvae) from the combined discharges of gaseous effluent from the Sizewell Site, deposited onto the marshland and its watershed, is calculated to be 2.7 µGy/h, with a corresponding RQ of 0.067. This dose rate is more than an order of magnitude below the current Environment Agency threshold dose rate of 40 µGy/h and is around an order of magnitude lower than the ERICA recommended screening dose rate of 10 µGy/h.

111. By comparison, the dose rates to the worst affected organisms inhabiting the local freshwater habitats of the Minsmere to Walberswick SPA, SAC and the Sandlings SPA, as calculated by the Environment Agency, were 0.31 and 3.6 µGy/h respectively. The dose rate for the Sandlings SPA organism is comparable to the worst dose rates due to the combined discharges from the Sizewell Site. The dose rate for the Minsmere to Walberswick SPA is approximately an order of magnitude below that arising from Sizewell Site discharges.

112. Table 7-11 below presents a summary of the assessed dose rates and the corresponding RQs for scrape organisms.

Table 7-11 Dose Rates to Habitat 5 (Marshland) Organisms due to the Combined Discharges of Gaseous Effluent from Sizewell B and C at Annual Limits

Organism	Total Dose Rate per organism [µGy/h]	Risk Quotient (expected value) [unitless]
Amphibian	5.3E-02	1.3E-03
Benthic fish	1.2E+00	3.1E-02
Bird	5.4E-02	1.4E-03
Crustacean	1.4E+00	3.4E-02
Insect larvae	2.7E+00	6.7E-02
Mammal	5.3E-02	1.3E-03
Mollusc - bivalve	1.3E+00	3.3E-02
Mollusc - gastropod	1.3E+00	3.4E-02
Pelagic fish	5.3E-02	1.3E-03
Phytoplankton	5.0E-02	1.2E-03
Reptile	1.2E+00	3.1E-02
Vascular plant	1.4E+00	3.4E-02
Zooplankton	5.1E-02	1.3E-03

113. The previous Environment Agency assessment generally predicted higher doses, but was based on much simpler (and more pessimistic) modelling and earlier assessment approaches which have been largely superseded.

8 CONCLUSION

114. The potential impact of routine operational aqueous and gaseous discharges from the proposed SZC nuclear power plant on a range of organisms representative of those inhabiting the areas close to the facility has been assessed. The assessment was based on the proposed annual discharge limits for SZC,

and the permitted discharge limits for the neighbouring SZB facility were used in the assessment of in-combination effects.

115. For all of the organisms evaluated, dose rates (biological impacts of ionising radiation) remained substantially lower than the current Environment Agency assessment threshold of 40 µGy/h. The dose rates were also lower than broader internationally considered thresholds. These included the:

- ERICA screening value that is considered protective of populations of NHB across all ecosystems (10 µGy/h); and
- Derived consideration reference levels, the most stringent of which is 4 µGy/h (for the duck, rat, deer and pine tree RAPs), applicable to planned exposure situations [Ref 41] [Ref 42].

116. The assessment results have shown the dose rate from SZC discharges to the worst affected organism (polychaete worm occupying a marine habitat) to be 0.80 µGy/h, with a RQ value of 0.020. The worst affected organism from the combined discharges of radioactive effluent from the SZB and SZC facilities (insect larvae occupying a marshland habitat) was 2.7 µGy/h, with a RQ value of 0.067. This dose rate is more than one order of magnitude below the current threshold dose rate of 40 µGy/h.

117. The impacts of radioactive effluent discharges on NHB from the proposed SZC nuclear power plant alone and in combination with SZB are therefore predicted to be very low. As such, based on the international recognised models used in this assessment, the output of which are well below regulatory threshold levels and furthermore comparable to or below previous assessments undertaken by the Environment Agency for the Natura 2000 sites, it can be concluded that there would be no significant effects on any Natura 2000 site and hence radiological effects are screened out of the Shadow Habitats Regulations Assessment. Likewise, no significant effects are predicted on any other ecological receptor or designated site, such as SSSIs.

APPENDIX A HABITAT SURVEY AREA

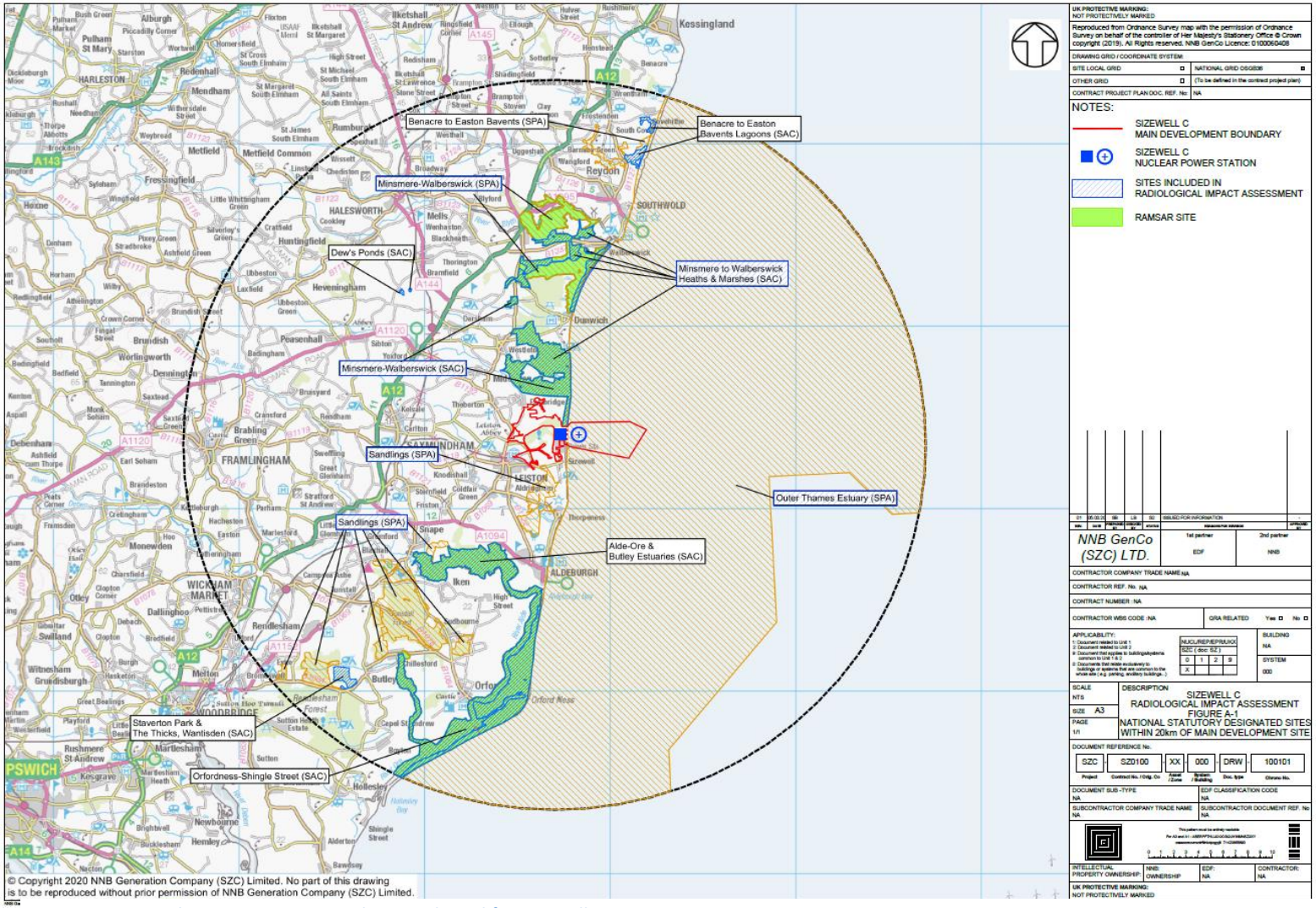

Figure A-1 National Statutory Designated Sites selected for Sizewell C RIA

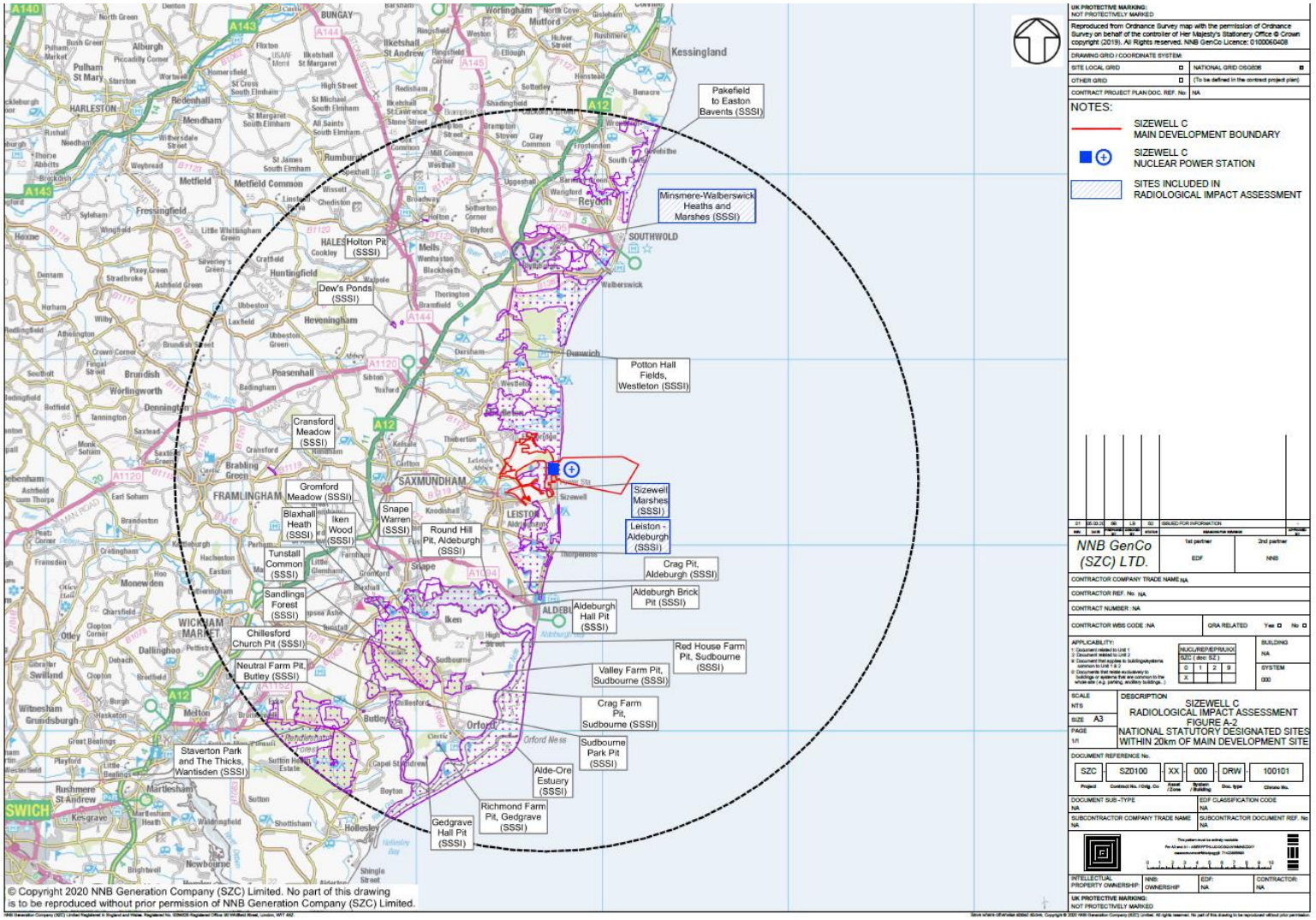

Figure A-2 International Statutory Designated Sites selected for Sizewell C RIA

APPENDIX B METEOROLOGICAL DATA

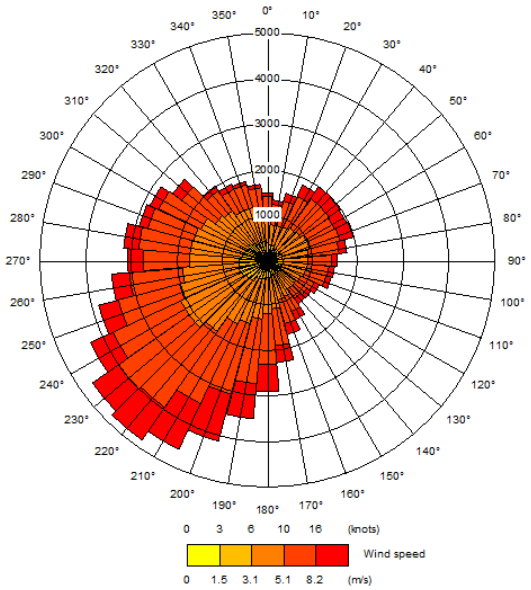

Figure B-3 Sizewell C Centred Windrose

Table B-1 10 Year (2003-2013) Meteorological Data in PC-CREAM 08 Format

Stability Category	Wind Angle (°)											
	15-45	45-75	75-105	105-135	135-165	165-195	195-225	225-255	255-285	285-315	315-345	345-15
A,	0	1.14E-5	1.14E-5	2.28E-5	1.14E-5	1.14E-5	1.14E-5	0	1.14E-5	1.14E-5	0	3.42E-5
B,	2.28E-4	2.40E-4	4.22E-4	3.99E-4	2.05E-4	2.05E-4	3.08E-4	1.59E-3	1.94E-3	1.90E-3	1.03E-3	4.56E-4
C,	6.98E-3	8.08E-3	8.89E-3	1.01E-2	5.74E-3	4.25E-3	6.98E-3	1.14E-2	8.81E-3	7.85E-3	8.69E-3	1.35E-2
D,	6.57E-2	6.87E-2	5.13E-2	4.31E-2	2.32E-2	1.67E-2	2.10E-2	2.34E-2	1.84E-2	1.42E-2	1.33E-2	3.49E-2
E,	3.21E-2	3.56E-2	2.54E-2	1.68E-2	1.02E-2	8.16E-3	8.73E-3	1.04E-2	1.11E-2	8.70E-3	9.78E-3	1.69E-2
F,	3.56E-3	4.35E-3	3.97E-3	3.05E-3	2.28E-3	2.25E-3	2.42E-3	2.26E-3	2.43E-3	2.67E-3	3.03E-3	3.07E-3
C+Rain,	1.64E-3	2.01E-3	1.73E-3	1.90E-3	1.76E-3	1.51E-3	1.53E-3	1.69E-3	1.09E-3	8.44E-4	1.00E-3	1.94E-3
D+Rain	4.44E-2	2.75E-2	1.85E-2	1.95E-2	2.16E-2	1.88E-2	2.01E-2	1.64E-2	1.12E-2	8.78E-3	1.27E-2	2.84E-2

APPENDIX C NHB ENVIRONMENTAL CONCENTRATION DATA

118. The tables below present the PC-CREAM 08 derived environmental concentration data used to assess the dose rates to NHB. All the data presented are based on a 60 year integration time.

C.1 Sizewell C Discharges

Table C-2 Radionuclide Concentrations in Unfiltered Seawater and Seabed Sediment (Local Compartment) from Sizewell C Discharges

Isotope	Activity concentration in water (Bq/l)	Activity concentration in seabed sediment (Bq/kg)
Ag-110m	9.78E-05	4.85E-03
C-14	1.74E-02	2.81E+01
Co-58	2.91E-04	4.88E-02
Co-60	4.93E-04	1.63E+00
Cr-51	7.38E-06	4.15E-04
Cs-134	9.72E-05	3.23E-02
Cs-137	1.73E-04	2.85E-01
H-3	1.84E+01	3.16E+01
I-131	4.17E-06	9.15E-07
Mn-54	4.15E-05	2.92E-02
Ni-63	1.68E-04	1.58E+00
Sb-124	7.54E-05	9.43E-04
Sb-125	1.44E-04	2.47E-02
Te-125m (Sb-125)*	2.07E-05	2.47E-02
Te-123m	4.29E-05	1.05E-03
Te-123 (Te-123m)*	1.33E-19	1.27E-15

* Progeny of the radionuclide shown in brackets

Table C-3 Radionuclide Concentration in Soil from Sizewell C Discharges at the Location of Habitat 1

Radionuclides	Dep. rates (Bq/m² per s) for annual discharge	Soil Concentration (Bq/kg)
Co-58	1.98E-09	4.82E-05
Co-60	2.33E-09	1.25E-03
Cs-134	1.82E-09	4.18E-04
Cs-137	1.63E-09	3.18E-03
I-131	3.56E-07	8.20E-04
I-133	6.89E-08	1.66E-05
Ba-137m (Cs-137)*	4.97E-10	2.44E-10
Cs-135 (Xe-135)*	1.26E-15	4.29E-09

*Progeny of the radionuclide in shown brackets

Table C-4 Radionuclide Concentration in Air from Sizewell C Discharges at the Location of Habitat 1

Radionuclide	Air Concentration (Bq/m³)
C-14	1.11E-01
H-3	4.75E-01

Table C-5 Discharge rates of Radionuclides to the Freshwater Scrape and Marshland from Sizewell C Discharges

Radionuclide	Deposition rate (Bq/m² per s) for annual discharge	Radionuclide discharge rate to scrape (Bq/s)	Radionuclide discharge rate to marshland (Bq/s)
C-14	0.00E+00	0.00E+00	0.00E+00
Co-58	1.94E-10	2.35E-05	1.08E-03
Co-60	2.28E-10	2.76E-05	1.27E-03
Cs-134	1.78E-10	2.16E-05	9.92E-04
Cs-137	1.59E-10	1.93E-05	8.90E-04
H-3	2.44E-04	2.96E+01	1.36E+03
I-131	2.67E-08	3.24E-03	1.49E-01
I-133	5.14E-09	6.24E-04	2.87E-02
Ba137m (Cs-137)*	1.39E-10	1.68E-05	7.75E-04
Cs-135 (Xe-135)*	7.37E-16	8.94E-11	4.11E-09

*Progeny of the radionuclide in shown brackets

C.2 Combined Sizewell B and C Discharges

Table C-6 Concentration of Radionuclides in Unfiltered Seawater and Seabed Sediment from Sizewell B and C Discharges

Radionuclide	Unfiltered seawater (Bq/l)	Seabed sediment (Bq/kg)
Ag-110m	9.78E-05	4.85E-03
C-14	1.74E-02	2.81E+01
Co-58	2.91E-04	4.88E-02
Co-60	4.93E-04	1.63E+00
Cr-51	7.38E-06	4.15E-04
Cs-134	1.16E-02	3.84E+00
Cs-137	1.99E-03	3.29E+00
H-3	2.57E+01	4.42E+01
I-131	4.17E-06	9.15E-07
Mn-54	4.15E-05	2.92E-02
Ni-63	1.68E-04	1.58E+00
Sb-124	7.54E-05	9.43E-04
Sb-125	1.44E-04	2.47E-02
Te-125m (Sb-125)*	2.07E-05	2.47E-02
Te-123m	4.29E-05	1.05E-03
Te-123 (Te-123m)*	1.33E-19	1.27E-15

*Progeny of the radionuclide shown in brackets

Table C-7 Concentration of Radionuclides in Soil from Sizewell B and C Discharges at the Location of Habitat 1

Radionuclides	Dep. rates (Bq/m²/s)	Soil Concentration (Bq/kg)
Co-58	1.98E-09	4.82E-05
Co-60	2.05E-08	1.10E-02
Cs-134	1.82E-09	4.18E-04
Cs-137	1.63E-09	3.18E-03
I-131	8.02E-07	1.84E-03
I-133	6.89E-08	1.66E-05
Ba-137m (Cs-137)*	4.97E-10	2.44E-10
Cs-135 (Xe-135)*	1.26E-15	4.29E-09

*Progeny of the radionuclide in shown brackets

Table C-8 Radionuclide Concentration in Air from Sizewell B and C Discharges at the Location of Habitat 1

Radionuclide	Air Concentration (Bq/m³)
C-14	1.51E-01
H-3	7.12E-01

Table C-9 Discharge rates of Radionuclides to the Freshwater Scrape and Marshland from Sizewell B and C Discharges

Radionuclide	Deposition rate (Bq/m2/s) for annual discharge	Radionuclide discharge rate to scrape	Radionuclide discharge rate to marshland
C-14	0.00E+00	0.00E+00	0.00E+00
Co-58	1.94E-10	2.35E-05	1.08E-03
Co-60	2.01E-09	2.44E-04	1.12E-02
Cs-134	1.78E-10	2.16E-05	9.92E-04
Cs-137	1.59E-10	1.93E-05	8.90E-04
H-3	3.66E-04	4.45E+01	2.05E+03
I-131	6.00E-08	7.28E-03	3.35E-01
I-133	5.14E-09	6.24E-04	2.87E-02
Ba137m (Cs-137)*	1.39E-10	1.68E-05	7.75E-04
Cs-135 (Xe-135)*	7.37E-16	8.94E-11	4.11E-09

*Progeny of the radionuclide in shown brackets

APPENDIX D NHB BREAKDOWN OF TOTAL DOSE RATES BY RADIONUCLIDE

Table D-10 Total Dose Rate (µGy/h) to Habitat 1 (Terrestrial) Organisms due to Gaseous Discharges from Sizewell C

Isotope	Amphibian	Annelid	Arthropod - detritivorous	Bat	Bird	Flying insects	Grasses & Herbs	Lichen & Bryophytes	Mammal - large	Mammal - small-burrowing	Mollusc - gastropod	Reptile	Shrub	Tree	Badger
C-14	4.2E-03	1.4E-03	1.4E-03	4.3E-03	4.4E-03	1.4E-03	2.8E-03	2.9E-03	4.4E-03	4.4E-03	1.4E-03	4.4E-03	2.8E-03	4.3E-03	4.4E-03
Co-58	2.5E-08	2.5E-08	2.5E-08	9.9E-09	9.7E-09	9.7E-09	9.2E-09	9.7E-09	8.1E-09	2.4E-08	9.7E-09	2.3E-08	8.7E-09	7.8E-09	1.4E-08
Co-60	1.7E-06	1.6E-06	1.6E-06	6.4E-07	6.2E-07	6.3E-07	6.0E-07	6.3E-07	5.3E-07	1.5E-06	6.3E-07	1.5E-06	5.6E-07	4.9E-07	9.4E-07
Cs-134	3.7E-07	3.5E-07	3.6E-07	2.9E-07	1.8E-07	1.4E-07	1.8E-07	2.7E-07	9.7E-07	5.7E-07	1.4E-07	3.5E-07	2.0E-07	1.4E-07	6.2E-07
Cs-137	1.2E-06	9.9E-07	1.0E-06	2.0E-06	6.9E-07	4.3E-07	8.5E-07	1.8E-06	3.9E-06	2.7E-06	4.0E-07	1.2E-06	1.2E-06	4.2E-07	2.9E-06
H-3	5.9E-04	5.9E-04	5.9E-04	5.9E-04	5.9E-04	5.5E-04	5.9E-04	5.9E-04	5.9E-04	5.9E-04	5.9E-04	5.9E-04	5.9E-04	5.9E-04	5.9E-04
I-131	2.0E-07	1.7E-07	1.8E-07	1.0E-07	1.1E-07	8.9E-08	7.6E-08	7.5E-08	1.1E-07	1.9E-07	8.0E-08	1.8E-07	5.9E-08	7.9E-08	1.4E-07
Ba-137m (Cs-137)*	7.7E-14	7.8E-14	7.9E-14	3.0E-14	2.9E-13	3.0E-14	2.9E-14	3.0E-14	1.6E-14	7.4E-14	3.0E-14	7.1E-14	3.3E-14	2.9E-14	4.0E-14
Cs-135 (Xe-135)*	7.8E-14	1.4E-14	1.8E-14	5.8E-13	9.6E-14	1.8E-14	1.9E-13	6.2E-13	5.8E-13	5.8E-13	6.9E-15	9.8E-14	3.3E-13	2.3E-14	5.8E-13
I-133	6.9E-09	5.9E-09	6.2E-09	3.6E-09	3.9E-09	3.0E-09	2.5E-09	2.5E-09	4.0E-09	6.7E-09	2.6E-09	6.5E-09	2.0E-09	2.6E-09	4.8E-09
Total	4.8E-03	2.0E-03	2.0E-03	4.9E-03	5.0E-03	1.9E-03	3.4E-03	3.4E-03	5.0E-03	5.0E-03	2.0E-03	5.0E-03	3.4E-03	4.9E-03	4.9E-03

*Progeny of the radionuclide in shown brackets

Table D-11 Total Dose Rate (µGy/ h) to Habitat 2 (Marine) Organisms due to Aqueous Discharges from Sizewell C

Isotope	Bird	Benthic fish	Crustacean	Macroalgae	Mammal	Mollusc - bivalve	Pelagic fish	Phytoplankton	Polychaete worm	Sea anemones & True coral	Vascular plant	Zooplankton
Ag-110m	5.6E-04	2.1E-03	2.6E-03	2.1E-03	1.9E-03	2.3E-03	2.3E-04	2.1E-04	4.4E-03	2.1E-03	2.0E-03	2.8E-05
C-14	8.7E-04	8.8E-04	7.2E-04	6.6E-04	8.7E-04	3.2E-04	8.7E-04	1.2E-04	5.0E-03	8.5E-04	6.5E-04	5.0E-03
Co-58	1.5E-05	5.9E-02	5.8E-02	6.4E-02	4.9E-05	6.3E-02	1.3E-04	1.6E-05	1.3E-01	6.4E-02	6.3E-02	3.5E-05
Co-60	6.0E-05	2.6E-01	2.6E-01	2.8E-01	1.9E-04	2.8E-01	5.0E-04	7.1E-05	5.5E-01	2.8E-01	2.8E-01	1.3E-04
Cr-51	1.5E-07	8.1E-06	7.8E-06	9.0E-06	2.7E-07	8.7E-06	1.4E-08	2.6E-07	1.8E-05	8.9E-06	8.9E-06	5.3E-08
Cs-134	1.0E-05	4.3E-04	4.1E-04	4.6E-04	1.3E-05	4.5E-04	1.6E-06	1.3E-07	9.1E-04	4.6E-04	4.5E-04	1.1E-06
Cs-137	1.6E-05	2.8E-04	2.7E-04	3.1E-04	1.3E-05	3.0E-04	2.7E-06	1.7E-07	6.1E-04	3.1E-04	3.0E-04	2.8E-06
H-3	1.5E-04	1.5E-04	1.5E-04	1.5E-04	1.5E-04	1.5E-04	1.5E-04	1.5E-04	1.5E-04	1.5E-04	1.5E-04	1.5E-04
I-131	1.2E-09	8.3E-08	9.7E-08	2.0E-06	1.1E-09	4.5E-06	5.7E-09	2.5E-07	4.2E-06	4.1E-06	9.4E-08	1.3E-06
Mn-54	1.4E-05	4.9E-02	4.8E-02	5.2E-02	5.0E-05	5.2E-02	6.1E-06	1.1E-06	1.0E-01	5.2E-02	5.1E-02	1.0E-06
Ni-63	1.0E-06	5.2E-07	2.6E-06	2.0E-06	1.0E-06	1.3E-05	5.2E-07	1.2E-06	8.7E-06	1.3E-05	2.0E-06	1.0E-06
Sb-124	2.2E-04	2.1E-04	2.0E-04	2.2E-04	4.7E-04	2.1E-04	1.4E-05	4.4E-06	5.2E-04	2.2E-04	2.0E-04	1.3E-05
Sb-125	1.2E-04	9.2E-05	8.5E-05	9.5E-05	2.4E-04	9.7E-05	8.0E-06	7.1E-06	2.3E-04	9.3E-05	9.4E-05	1.1E-05
Te-123 (Te-123m)*	1.6E-20	2.3E-21	2.8E-21	2.2E-21	2.0E-20	3.7E-21	1.3E-21	1.4E-20	9.3E-21	1.8E-21	2.2E-21	1.1E-21
Te-123m	2.8E-05	6.4E-06	7.3E-06	5.9E-06	4.3E-05	8.9E-06	2.2E-06	3.3E-05	2.2E-05	4.8E-06	5.8E-06	2.7E-06
Te-125m (Sb-125)*	1.5E-05	1.5E-06	2.0E-06	1.2E-06	1.6E-05	2.9E-06	1.2E-06	1.9E-05	8.2E-06	5.4E-07	1.1E-06	1.5E-06
Total	2.1E-03	3.7E-01	3.7E-01	4.0E-01	4.0E-03	3.9E-01	1.9E-03	6.3E-04	8.0E-01	4.0E-01	3.9E-01	5.4E-03

*Progeny of the radionuclide in shown brackets

Table D-12 Total Dose Rate (µGy/h) to Habitat 4 (Scrape) Organisms due to Gaseous Discharges from Sizewell C

Isotope	Amphibian	Benthic fish	Bird	Crustacean	Insect larvae	Mammal	Mollusc - bivalve	Mollusc - gastropod	Pelagic fish	Phytoplankton	Reptile	Vascular plant	Zooplankton
C-14	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Co-58	3.0E-08	7.0E-05	1.9E-07	8.0E-05	1.6E-04	8.8E-08	7.6E-05	7.8E-05	5.7E-08	3.1E-08	7.0E-05	8.0E-05	9.3E-08
Co-60	2.2E-06	5.9E-03	1.4E-05	6.4E-03	1.3E-02	6.3E-06	6.4E-03	6.4E-03	4.1E-06	2.6E-06	5.8E-03	6.4E-03	7.4E-06
Cs-134	1.3E-05	1.4E-03	1.3E-05	1.6E-03	3.2E-03	1.6E-05	1.5E-03	1.5E-03	1.8E-05	2.0E-07	1.4E-03	1.6E-03	1.5E-07
Cs-137	1.5E-04	5.0E-03	1.1E-04	6.4E-03	1.3E-02	1.2E-04	5.3E-03	5.7E-03	1.5E-04	2.4E-06	5.0E-03	6.3E-03	1.8E-06
H-3	1.6E-03	1.6E-03	1.6E-03	1.6E-03	1.6E-03	1.6E-03	1.6E-03	1.6E-03	1.6E-03	1.6E-03	1.6E-03	1.6E-03	1.6E-03
I-131	1.5E-06	5.5E-04	2.3E-07	7.2E-04	1.4E-03	2.0E-06	6.0E-04	6.3E-04	1.8E-06	1.5E-07	5.4E-04	7.2E-04	2.5E-07
I-133	6.4E-08	1.9E-05	9.4E-09	2.8E-05	5.6E-05	8.3E-08	2.0E-05	2.2E-05	7.5E-08	3.2E-09	1.8E-05	2.7E-05	5.8E-09
Ba-137m (Cs-137)*	4.2E-13	3.2E-11	1.4E-11	3.9E-11	7.7E-11	9.0E-13	3.7E-11	3.8E-11	6.6E-13	3.2E-14	3.2E-11	3.8E-11	5.2E-13
Cs-135 (Xe-135)*	3.3E-10	2.9E-10	1.9E-10	4.7E-10	7.4E-10	1.9E-10	2.5E-11	5.0E-11	2.8E-10	1.1E-11	3.3E-10	4.2E-10	6.9E-12
Total	1.8E-03	1.5E-02	1.8E-03	1.7E-02	3.2E-02	1.8E-03	1.6E-02	1.6E-02	1.8E-03	1.6E-03	1.4E-02	1.7E-02	1.6E-03

*Progeny of the radionuclide in shown brackets

Table D-13 Total Dose Rate (µGy/ h) to Habitat 5 (Marshland) Organisms due to Gaseous Discharges from Sizewell C

Isotope	Amphibian	Benthic fish	Bird	Crustacean	Insect larvae	Mammal	Mollusc - bivalve	Mollusc - gastropod	Pelagic fish	Phytoplankton	Reptile	Vascular plant	Zooplankton
C-14	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Co-58	6.0E-07	1.4E-03	3.7E-06	1.6E-03	3.2E-03	1.7E-06	1.5E-03	1.6E-03	1.1E-06	6.2E-07	1.4E-03	1.6E-03	1.9E-06
Co-60	4.4E-05	1.2E-01	2.8E-04	1.3E-01	2.5E-01	1.3E-04	1.3E-01	1.3E-01	8.2E-05	5.1E-05	1.2E-01	1.3E-01	1.5E-04
Cs-134	2.6E-04	2.8E-02	2.5E-04	3.2E-02	6.5E-02	3.2E-04	3.0E-02	3.1E-02	3.6E-04	4.1E-06	2.8E-02	3.2E-02	3.1E-06
Cs-137	2.9E-03	9.9E-02	2.1E-03	1.3E-01	2.6E-01	2.3E-03	1.1E-01	1.1E-01	3.0E-03	4.9E-05	1.0E-01	1.3E-01	3.5E-05
H-3	3.3E-02	3.3E-02	3.3E-02	3.3E-02	3.3E-02	3.3E-02	3.3E-02	3.3E-02	3.3E-02	3.3E-02	3.3E-02	3.3E-02	3.3E-02
I-131	3.1E-05	1.1E-02	4.5E-06	1.4E-02	2.7E-02	4.1E-05	1.2E-02	1.3E-02	3.6E-05	3.0E-06	1.1E-02	1.4E-02	5.0E-06
I-133	1.3E-06	3.7E-04	1.9E-07	5.6E-04	1.1E-03	1.6E-06	4.1E-04	4.4E-04	1.5E-06	6.4E-08	3.7E-04	5.4E-04	1.2E-07
Ba-137m (Cs-137)*	8.4E-12	6.4E-10	2.8E-10	7.8E-10	1.5E-09	1.8E-11	7.4E-10	7.6E-10	1.3E-11	6.5E-13	6.3E-10	7.6E-10	1.0E-11
Cs-135 (Xe-135)*	6.6E-09	5.7E-09	3.8E-09	9.3E-09	1.5E-08	3.8E-09	5.1E-10	1.0E-09	5.6E-09	2.1E-10	6.7E-09	8.5E-09	1.4E-10
Total	3.6E-02	2.9E-01	3.5E-02	3.4E-01	6.4E-01	3.5E-02	3.1E-01	3.2E-01	3.6E-02	3.3E-02	2.9E-01	3.4E-01	3.3E-02

*Progeny of the radionuclide in shown brackets

Table D-14 Total Dose Rate (µGy/ h) to Habitat 1 (Terrestrial) Organisms due to Gaseous Discharges from Sizewell B and C

Isotope	Amphibian	Annelid	Arthropod - detritivorous	Bat	Bird	Flying insects	Grasses & Herbs	Lichen & Bryophytes	Mammal - large	Mammal - small- burrowing	Mollusc - gastropod	Reptile	Shrub	Tree	Badger
C-14	5.8E-03	1.9E-03	1.9E-03	5.9E-03	6.0E-03	1.9E-03	3.8E-03	3.9E-03	6.0E-03	6.0E-03	1.9E-03	6.0E-03	3.8E-03	5.8E-03	5.9E-03
Co-58	2.5E-08	2.5E-08	2.5E-08	9.9E-09	9.7E-09	9.7E-09	9.2E-09	9.7E-09	8.1E-09	2.4E-08	9.7E-09	2.3E-08	8.7E-09	7.8E-09	1.4E-08
Co-60	1.5E-05	1.4E-05	1.4E-05	5.6E-06	5.4E-06	5.5E-06	5.3E-06	5.5E-06	4.6E-06	1.4E-05	5.5E-06	1.4E-05	5.0E-06	4.3E-06	8.3E-06
Cs-134	3.7E-07	3.5E-07	3.6E-07	2.9E-07	1.8E-07	1.4E-07	1.8E-07	2.7E-07	9.7E-07	5.7E-07	1.4E-07	3.5E-07	2.0E-07	1.4E-07	6.2E-07
Cs-137	1.2E-06	9.9E-07	1.0E-06	2.0E-06	6.9E-07	4.3E-07	8.5E-07	1.8E-06	3.9E-06	2.7E-06	4.0E-07	1.2E-06	1.2E-06	4.2E-07	2.9E-06
H-3	8.8E-04	8.8E-04	8.8E-04	8.8E-04	8.8E-04	8.2E-04	8.8E-04	8.8E-04	8.8E-04	8.8E-04	8.8E-04	8.8E-04	8.8E-04	8.8E-04	8.8E-04
I-131	4.4E-07	3.8E-07	4.1E-07	2.3E-07	2.4E-07	2.0E-07	1.7E-07	1.7E-07	2.5E-07	4.3E-07	1.8E-07	4.1E-07	1.3E-07	1.8E-07	3.0E-07
Ba-137m (Cs-137)*	7.7E-14	7.8E-14	7.9E-14	3.0E-14	2.9E-13	3.0E-14	2.9E-14	3.0E-14	1.6E-14	7.4E-14	3.0E-14	7.1E-14	3.3E-14	2.9E-14	4.0E-14
Cs-135 (Xe-135)*	7.8E-14	1.4E-14	1.8E-14	5.8E-13	9.6E-14	1.8E-14	1.9E-13	6.2E-13	5.8E-13	5.8E-13	6.9E-15	9.8E-14	3.3E-13	2.3E-14	5.8E-13
I-133	6.9E-09	5.9E-09	6.2E-09	3.6E-09	3.9E-09	3.0E-09	2.5E-09	2.5E-09	4.0E-09	6.7E-09	2.6E-09	6.5E-09	2.0E-09	2.6E-09	4.8E-09
Total	6.7E-03	2.7E-03	2.8E-03	6.8E-03	6.9E-03	2.7E-03	4.7E-03	4.8E-03	6.9E-03	6.9E-03	2.7E-03	6.9E-03	4.7E-03	6.7E-03	6.8E-03

*Progeny of the radionuclide in shown brackets

Table D-15 Total Dose Rate (µGy/ h) to Habitat 2 (Marine) Organisms due to Aqueous Discharges from Sizewell B and C

Isotope	Bird	Benthic fish	Crustacean	Macroalgae	Mammal	Mollusc - bivalve	Pelagic fish	Phytoplankton	Polychaete worm	Sea anemones & True coral	Vascular plant	Zooplankton
Ag-110m	5.6E-04	2.1E-03	2.6E-03	2.1E-03	1.9E-03	2.3E-03	2.3E-04	2.1E-04	4.4E-03	2.1E-03	2.0E-03	2.8E-05
C-14	8.7E-04	8.8E-04	7.2E-04	6.6E-04	8.7E-04	3.2E-04	8.7E-04	1.2E-04	5.0E-03	8.5E-04	6.5E-04	5.0E-03
Co-58	1.5E-05	5.9E-02	5.8E-02	6.4E-02	4.9E-05	6.3E-02	1.3E-04	1.6E-05	1.3E-01	6.4E-02	6.3E-02	3.5E-05
Co-60	6.0E-05	2.6E-01	2.6E-01	2.8E-01	1.9E-04	2.8E-01	5.0E-04	7.1E-05	5.5E-01	2.8E-01	2.8E-01	1.3E-04
Cr-51	1.5E-07	8.1E-06	7.8E-06	9.0E-06	2.7E-07	8.7E-06	1.4E-08	2.6E-07	1.8E-05	8.9E-06	8.9E-06	5.3E-08
Cs-134	1.2E-03	5.1E-02	4.9E-02	5.5E-02	1.5E-03	5.4E-02	1.9E-04	1.6E-05	1.1E-01	5.5E-02	5.4E-02	1.4E-04
Cs-137	1.8E-04	3.2E-03	3.1E-03	3.5E-03	1.4E-04	3.4E-03	3.1E-05	1.9E-06	7.0E-03	3.6E-03	3.4E-03	3.2E-05
H-3	2.1E-04	2.1E-04	2.1E-04	2.1E-04	2.1E-04	2.1E-04	2.1E-04	2.1E-04	2.1E-04	2.1E-04	2.1E-04	2.1E-04
I-131	1.2E-09	8.3E-08	9.7E-08	2.0E-06	1.1E-09	4.5E-06	5.7E-09	2.5E-07	4.2E-06	4.1E-06	9.4E-08	1.3E-06
Mn-54	1.4E-05	4.9E-02	4.8E-02	5.2E-02	5.0E-05	5.2E-02	6.1E-06	1.1E-06	1.0E-01	5.2E-02	5.1E-02	1.0E-06
Ni-63	1.0E-06	5.2E-07	2.6E-06	2.0E-06	1.0E-06	1.3E-05	5.2E-07	1.2E-06	8.7E-06	1.3E-05	2.0E-06	1.0E-06
Sb-124	2.2E-04	2.1E-04	2.0E-04	2.2E-04	4.7E-04	2.1E-04	1.4E-05	4.4E-06	5.2E-04	2.2E-04	2.0E-04	1.3E-05
Sb-125	1.2E-04	9.2E-05	8.5E-05	9.5E-05	2.4E-04	9.7E-05	8.0E-06	7.1E-06	2.3E-04	9.3E-05	9.4E-05	1.1E-05
Te-123 (Te-123m)*	1.6E-20	2.3E-21	2.8E-21	2.2E-21	2.0E-20	3.7E-21	1.3E-21	1.4E-20	9.3E-21	1.8E-21	2.2E-21	1.1E-21
Te-123m	2.8E-05	6.4E-06	7.3E-06	5.9E-06	4.3E-05	8.9E-06	2.2E-06	3.3E-05	2.2E-05	4.8E-06	5.8E-06	2.7E-06
Te-125m (Sb-125)*	1.5E-05	1.5E-06	2.0E-06	1.2E-06	1.6E-05	2.9E-06	1.2E-06	1.9E-05	8.2E-06	5.4E-07	1.1E-06	1.5E-06
Total	3.5E-03	4.2E-01	4.2E-01	4.6E-01	5.7E-03	4.5E-01	2.2E-03	7.1E-04	9.1E-01	4.5E-01	4.5E-01	5.6E-03

*Progeny of the radionuclide in shown brackets

Table D-16 Total Dose Rate (µGy/ h) to Habitat 4 (Scrape) Organisms due to Gaseous Discharges from Sizewell B and C

Isotope	Amphibian	Benthic fish	Bird	Crustacean	Insect larvae	Mammal	Mollusc - bivalve	Mollusc - gastropod	Pelagic fish	Phytoplankton	Reptile	Vascular plant	Zooplankton
C-14	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Co-58	3.0E-08	7.0E-05	1.9E-07	8.0E-05	1.6E-04	8.8E-08	7.6E-05	7.8E-05	5.7E-08	3.1E-08	7.0E-05	8.0E-05	9.3E-08
Co-60	1.9E-05	5.2E-02	1.2E-04	5.6E-02	1.1E-01	5.6E-05	5.6E-02	5.6E-02	3.6E-05	2.3E-05	5.1E-02	5.6E-02	6.5E-05
Cs-134	1.3E-05	1.4E-03	1.3E-05	1.6E-03	3.2E-03	1.6E-05	1.5E-03	1.5E-03	1.8E-05	2.0E-07	1.4E-03	1.6E-03	1.5E-07
Cs-137	1.5E-04	5.0E-03	1.1E-04	6.4E-03	1.3E-02	1.2E-04	5.3E-03	5.7E-03	1.5E-04	2.4E-06	5.0E-03	6.3E-03	1.8E-06
H-3	2.5E-03	2.5E-03	2.5E-03	2.5E-03	2.5E-03	2.5E-03	2.5E-03	2.5E-03	2.5E-03	2.5E-03	2.5E-03	2.5E-03	2.5E-03
I-131	3.5E-06	1.2E-03	5.1E-07	1.6E-03	3.1E-03	4.6E-06	1.4E-03	1.4E-03	4.0E-06	3.4E-07	1.2E-03	1.6E-03	5.6E-07
I-133	6.4E-08	1.9E-05	9.4E-09	2.8E-05	5.6E-05	8.3E-08	2.0E-05	2.2E-05	7.5E-08	3.2E-09	1.8E-05	2.7E-05	5.8E-09
Ba-137m (Cs-137)*	4.2E-13	3.2E-11	1.4E-11	3.9E-11	7.7E-11	9.0E-13	3.7E-11	3.8E-11	6.6E-13	3.2E-14	3.2E-11	3.8E-11	5.2E-13
Cs-135 (Xe-135)*	3.3E-10	2.9E-10	1.9E-10	4.7E-10	7.4E-10	1.9E-10	2.5E-11	5.0E-11	2.8E-10	1.1E-11	3.3E-10	4.2E-10	6.9E-12
Total	2.6E-03	6.2E-02	2.7E-03	6.9E-02	1.3E-01	2.7E-03	6.7E-02	6.8E-02	2.7E-03	2.5E-03	6.1E-02	6.8E-02	2.5E-03

*Progeny of the radionuclide in shown brackets

Table D-17 Total Dose Rate (µGy/ h) to Habitat 5 (Marshland) Organisms due to Gaseous Discharges from Sizewell B and C

Isotope	Amphibian	Benthic fish	Bird	Crustacean	Insect larvae	Mammal	Mollusc - bivalve	Mollusc - gastropod	Pelagic fish	Phytoplankton	Reptile	Vascular plant	Zooplankton
C-14	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Co-58	6.0E-07	1.4E-03	3.7E-06	1.6E-03	3.2E-03	1.7E-06	1.5E-03	1.6E-03	1.1E-06	6.2E-07	1.4E-03	1.6E-03	1.9E-06
Co-60	3.9E-04	1.0E+00	2.4E-03	1.1E+00	2.2E+00	1.1E-03	1.1E+00	1.1E+00	7.2E-04	4.5E-04	1.0E+00	1.1E+00	1.3E-03
Cs-134	2.6E-04	2.8E-02	2.5E-04	3.2E-02	6.5E-02	3.2E-04	3.0E-02	3.1E-02	3.6E-04	4.1E-06	2.8E-02	3.2E-02	3.1E-06
Cs-137	2.9E-03	9.9E-02	2.1E-03	1.3E-01	2.6E-01	2.3E-03	1.1E-01	1.1E-01	3.0E-03	4.9E-05	1.0E-01	1.3E-01	3.5E-05
H-3	4.9E-02	4.9E-02	4.9E-02	4.9E-02	4.9E-02	4.9E-02	4.9E-02	4.9E-02	4.9E-02	4.9E-02	4.9E-02	4.9E-02	4.9E-02
I-131	6.9E-05	2.5E-02	1.0E-05	3.2E-02	6.2E-02	9.2E-05	2.7E-02	2.8E-02	8.1E-05	6.7E-06	2.4E-02	3.2E-02	1.1E-05
I-133	1.3E-06	3.7E-04	1.9E-07	5.6E-04	1.1E-03	1.6E-06	4.1E-04	4.4E-04	1.5E-06	6.4E-08	3.7E-04	5.4E-04	1.2E-07
Ba-137m (Cs-137)*	8.4E-12	6.4E-10	2.8E-10	7.8E-10	1.5E-09	1.8E-11	7.4E-10	7.6E-10	1.3E-11	6.5E-13	6.3E-10	7.6E-10	1.0E-11
Cs-135 (Xe-135)*	6.6E-09	5.7E-09	3.8E-09	9.3E-09	1.5E-08	3.8E-09	5.1E-10	1.0E-09	5.6E-09	2.1E-10	6.7E-09	8.5E-09	1.4E-10
Total	5.3E-02	1.2E+00	5.4E-02	1.4E+00	2.7E+00	5.3E-02	1.3E+00	1.3E+00	5.3E-02	5.0E-02	1.2E+00	1.4E+00	5.1E-02

*Progeny of the radionuclide in shown brackets

Table D-18 Total Dose Rate (µGy/ h) to Habitat 1 (Terrestrial) Organisms due to Discharges of Noble Gases from Sizewell C and from the Combined Sizewell Site Discharges

Organism	SZC Discharges			Combined Sizewell B and C Discharges		
	Ar-41 Dose Rate	Kr-85 Dose Rate	Total Dose Rate per organism	Ar-41 Dose Rate	Kr-85 Dose Rate	Total Dose Rate per organism
Bacteria	2.8E-7	6.6E-9	2.9E-7	5.0E-7	6.6E-9	5.1E-7
Lichen	9.5E-4	3.9E-6	9.5E-4	1.7E-3	3.9E-6	1.7E-3
Tree	1.0E-3	8.7E-6	1.0E-3	1.8E-3	8.7E-6	1.8E-3
Shrub	1.0E-3	8.7E-6	1.0E-03	1.8E-3	8.7E-6	1.8E-3
Herb	1.0E-3	8.7E-6	1.0E-3	1.8E-3	8.7E-6	1.8E-3
Seed	1.1E-3	1.4E-5	1.1E-3	1.9E-3	1.4E-5	2.0E-3
Fungi	1.2E-3	2.7E-5	1.2E-3	2.1E-3	2.7E-5	2.1E-3
Caterpillar	1.8E-3	5.4E-6	1.8E-3	3.3E-3	5.4E-6	3.3E-3
Ant	7.0E-4	4.8E-6	7.1E-4	1.2E-3	4.8E-6	1.2E-3
Bee	1.7E-3	3.0E-6	1.7E-3	3.0E-3	3.0E-6	3.0E-3
Woodlouse	9.6E-4	4.6E-6	9.6E-4	1.7E-3	4.6E-6	1.7E-3
Earthworm	2.2E-7	6.3E-10	2.2E-7	3.9E-7	6.3E-10	3.9E-7
Herb. Mammal	3.7E-4	1.7E-7	3.7E-4	6.6E-4	1.7E-7	6.6E-4
Car. Mammal	4.4E-4	1.9E-7	4.4E-4	7.7E-4	1.9E-7	7.7E-4
Rodent	3.5E-4	4.0E-7	3.5E-4	6.1E-4	4.0E-7	6.1E-4
Bird	1.2E-3	5.0E-7	1.2E-3	2.1E-3	5.0E-7	2.1E-3
Bird egg	8.6E-4	9.2E-7	8.6E-4	1.5E-3	9.2E-7	1.5E-3
Reptile	4.8E-4	2.9E-7	4.8E-4	8.4E-4	2.9E-7	8.4E-4

APPENDIX E MODEL PARAMETERS

E.1 Habitat 1 input parameters

Table E-19 Terrestrial Concentration Ratio (Bq kg-1 (f.w.) per Bq kg-1 soil (d.w.) or Bq m-3 air for H and C)

Nuclide	Amphibian	Annelid	Arthropod - detritivorous	Bat	Bird	Flying insects	Grasses & Herbs	Lichen & Bryophytes	Mammal - large	Mammal - small-burrowing	Mollusc - gastropod	Reptile	Shrub	Tree	Badger
C	1.34E+03	4.29E+02	4.30E+02	1.34E+03	1.34E+03	4.30E+02	8.90E+02	8.90E+02	1.34E+03	1.34E+03	4.30E+02	1.34E+03	8.90E+02	1.30E+03	1.34E+03
Co	1.91E-01	1.88E-02	7.07E-03	1.91E-01	1.30E-02	7.07E-03	1.93E-02	8.40E-02	1.91E-01	1.91E-01	1.88E-02	1.91E-01	1.30E-02	5.43E-03	1.91E-01
Cs	4.57E-01	8.10E-02	1.06E-01	3.41E+00	5.63E-01	1.06E-01	1.12E+00	3.78E+00	3.41E+00	3.41E+00	4.05E-02	5.74E-01	1.96E+00	1.36E-01	3.41E+00
H	1.50E+02	1.50E+02	1.50E+02	1.50E+02	1.50E+02	1.50E+02	1.50E+02	1.50E+02	1.50E+02	1.50E+02	1.50E+02	1.50E+02	1.50E+02	1.50E+02	1.50E+02
I	4.00E-01	1.56E-01	3.01E-01	4.00E-01	4.00E-01	3.01E-01	1.40E-01	1.40E-01	4.00E-01	4.00E-01	1.80E-01	4.00E-01	7.03E-04	1.40E-01	4.00E-01

Table E-20 Terrestrial Occupancy Factor (unitless)

Habitat	Amphibian	Annelid	Arthropod - detritivorous	Bat	Bird	Flying insects	Grasses & Herbs	Lichen & Bryophytes	Mammal - large	Mammal - small-burrowing	Mollusc - gastropod	Reptile	Shrub	Tree	Badger
On-soil	0	0	0	1	1	1	1	1	1	0	1	0	1	1	0.5
In-soil	1	1	1	0	0	0	0	0	0	1	0	1	0	0	0.5
In-air	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table E-21 Reference Organism Specific Data (Terrestrial Ecosystem)

Organism	Mass	Default Geometries		
	(kg)	Length (cm)	Height (cm)	Width (cm)
Amphibian (ICRP Frog)	3.14E-02	7.99E+00	3.00E+00	2.50E+00
Annelid (ICRP Earthworm)	5.24E-03	1.00E+01	1.00E+00	1.00E+00
Arthropod - detritivorous (FASSET Woodlouse)	1.70E-04	1.74E+00	6.13E-01	3.05E-01
Bat[14]	7.00E-03	4.10E+00	1.20E+00	1.20E+00
Bird (ICRP Duck)	1.26E+00	3.00E+01	1.00E+01	8.02E+00
Flying insects (ICRP Bee)	5.89E-04	2.00E+00	7.50E-01	7.50E-01
Grasses & Herbs (ICRP Wild grass)	2.62E-03	5.00E+00	1.00E+00	1.00E+00
Lichen & Bryophytes (ICRP Bryophyte)	1.70E-04	4.01E+00	2.29E-01	2.29E-01
Mammal - large (ICRP Deer)	2.45E+02	1.30E+02	6.00E+01	6.00E+01
Mammal - small-burrowing (ICRP Rat)	3.14E-01	2.00E+01	6.00E+00	5.00E+00
Mollusc - gastropod (ICRP Snail)	1.40E-03	1.88E+00	1.54E+00	9.27E-01
Reptile (FASSET snake note this is an ellipsoid)	7.44E-01	1.16E+02	3.49E+00	3.49E+00
Shrub	2.62E-03	5.00E+00	1.00E+00	1.00E+00
Tree (ICRP Pine tree)	4.71E+02	1.00E+03	3.00E+01	3.00E+01
Badger[14]	6.60E+00	7.30E+01	3.00E+01	2.50E+01

[14] Badger and bat from reference [16].

E.2 Habitat 2 input parameters

Table E-22 Marine Concentration Ratio (Bq kg-1 (f.w.) per Bq l-1)

Nuclide	Bird	Benthic fish	Crustacean	Macroalgae	Mammal	Mollusc - bivalve	Pelagic fish	Phytoplankton	Polychaete worm	Sea anemones & True coral	Vascular plant	Zooplankton
Ag	2.20E+04	1.10E+04	3.60E+04	3.90E+03	2.20E+04	3.60E+04	1.10E+04	6.90E+04	2.70E+04	1.30E+02	3.90E+03	6.00E+03
C	1.70E+03	1.70E+03	1.40E+03	1.30E+03	1.70E+03	6.50E+02	1.70E+03	2.50E+02	1.00E+04	1.70E+03	1.30E+03	1.00E+04
Co	5.00E+02	5.30E+03	3.50E+03	1.70E+03	5.00E+02	5.30E+03	5.30E+03	3.10E+03	8.03E+03	6.08E+02	3.28E+02	4.80E+03
Cr	2.00E+03	2.00E+02	1.00E+02	6.00E+03	2.00E+03	2.00E+03	2.00E+02	5.00E+03	2.00E+03	2.00E+03	6.00E+03	1.00E+03
Cs	4.80E+02	8.40E+01	5.30E+01	9.60E+01	2.20E+02	5.00E+01	8.40E+01	8.50E+00	1.80E+02	2.30E+02	1.00E+01	1.30E+02
H	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
I	6.80E-01	9.00E+00	3.92E+01	4.20E+03	6.80E-01	8.80E+03	9.00E+00	9.50E+02	8.80E+03	8.80E+03	2.40E+01	3.10E+03
Mn	4.50E+03	2.60E+03	4.50E+04	8.60E+03	4.50E+03	1.20E+04	2.60E+03	3.50E+03	3.20E+03	1.00E+01	3.00E+04	2.50E+03
Ni	5.00E+02	2.50E+02	1.27E+03	9.50E+02	5.00E+02	6.40E+03	2.50E+02	5.70E+02	4.20E+03	6.40E+03	9.50E+02	5.00E+02
Sb	8.30E+03	6.00E+02	3.00E+02	2.25E+02	8.30E+03	4.70E+02	6.00E+02	1.00E+03	4.50E+03	9.00E+01	2.25E+02	1.31E+03
Te	8.30E+03	6.90E+02	1.00E+03	4.25E+02	8.30E+03	1.50E+03	6.90E+02	1.31E+04	4.50E+03	1.00E+01	4.25E+02	1.00E+03

Table E-23 Marine Occupancy Factor (unitless)

Habitat	Bird	Benthic fish	Crustacean	Macroalgae	Mammal	Mollusc - bivalve	Pelagic fish	Phytoplankton	Polychaete worm	Sea anemones & True coral	Vascular plant	Zooplankton
Water-surface	0	0	0	0	0	0	0	0	0	0	0	0
Water	1	0	0	0	1	0	1	1	0	0	0	1
Sediment-surface	0	1	1	1	0	1	0	0	0	1	1	0
Sediment	0	0	0	0	0	0	0	0	1	0	0	0

Table E-24 Reference Organism Specific Data (Marine Ecosystem)

Organism	Mass	Default Geometries		
	(kg)	Length (cm)	Height (cm)	Width (cm)
Benthic fish (ICRP Flat fish)	1.31E+00	3.99E+01	2.49E+01	2.51E+00
Bird (ICRP Duck, Wading bird)	1.26E+00	3.00E+01	1.00E+01	8.02E+00
Crustacean (ICRP Crab)	7.54E-01	2.00E+01	1.20E+01	6.00E+00
Macroalgae (ICRP Brown seaweed)	6.52E-01	5.00E+01	5.00E-01	5.00E-01
Mammal (FASSET Mammal)	1.82E+02	1.80E+02	4.39E+01	4.39E+01
Mollusc - bivalve (FASSET Benthic mollusc)	1.64E-02	5.00E+00	2.50E+00	2.50E+00
Pelagic fish (FASSET Pelagic fish)	5.65E-01	3.00E+01	6.00E+00	6.00E+00

Phytoplankton (ERICA Phytoplankton)[15]	1.00E-06	5.00E-03	5.00E-03	5.00E-03
Polychaete worm (FASSET Benthic worm)	1.73E-02	2.30E+01	1.20E+00	1.20E+00
Sea anemones & True coral (ICRP Polyp)	1.77E-03	1.50E+00	1.50E+00	1.50E+00
Vascular plant (FASSET Vascular plant)	2.62E-02	9.29E+00	2.32E+00	2.32E+00
Zooplankton (FASSET Zooplankton)	6.14E-05	6.20E-01	6.10E-01	3.10E-01

E.3 Habitats 4 and 5 input parameters

Table E-25 Scrape and Marshland Concentration Ratios [Bq/kg(f.w.) per Bq/l]

Nuclide	Amphibian	Benthic fish	Bird	Crustacean	Insect larvae	Mammal	Mollusc - bivalve	Mollusc - gastropod	Pelagic fish	Phytoplankton	Reptile	Vascular plant	Zooplankton
C	1.80E+05	1.80E+05	1.80E+05	1.80E+05	1.80E+05	1.80E+05	1.80E+05	1.80E+05	1.80E+05	4.00E+03	1.80E+05	8.80E+03	1.80E+05
Co	2.31E+02	2.31E+02	7.00E+02	1.85E+03	1.85E+03	2.31E+02	1.05E+03	1.05E+03	2.31E+02	6.46E+02	1.22E+01	9.28E+02	1.85E+03
Cs	3.95E+03	3.37E+03	2.27E+03	1.81E+03	1.99E+03	2.27E+03	1.29E+02	1.29E+02	3.37E+03	1.42E+02	3.95E+03	3.59E+02	8.97E+01
H	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
I	3.19E+02	3.19E+02	3.91E+01	8.31E+01	8.31E+01	3.19E+02	8.31E+01	8.31E+01	3.19E+02	5.41E+01	3.19E+02	5.41E+01	8.31E+01

[15] For technical reasons the default mass of both marine and freshwater phytoplankton in ERICA has been set to 1.00E-06 Kg replacing the old values of 6.54E-11 kg and 2.05E-12 kg for FASSET marine and freshwater phytoplankton respectively. This is a relatively small geometry and can be considered to represent an accreted mass of phytoplankton cells.

Table E-26 Scrape and Marshland Occupancy Factor (unitless)

Habitat	Amphibian	Benthic fish	Bird	Crustacean	Insect larvae	Mammal	Mollusc - bivalve	Mollusc - gastropod	Pelagic fish	Phytoplankton	Reptile	Vascular plant	Zooplankton
Water-surface	0	0	0	0	0	0	0	0	0	0	0	0	0
Water	1	0	1	0	0	1	0	0	1	1	0.5	0	1
Sediment-surface	0	1	0	1	0	0	1	1	0	0	0	1	0
Sediment	0	0	0	0	1	0	0	0	0	0	0.5	0	0

Table E-27 Scrape and Marshland Distribution Coefficients [l kg-1]

Nuclide	Distribution Coefficient (Kd)
C	13.31916464
Co	111087.5049
Cs	140123.4408
H	1
I	143153.336

Table E-28 Reference Organism Specific Data (Freshwater Ecosystem)

Organism	Mass	Default Geometries		
	(kg)	Length (cm)	Height (cm)	Width (cm)
Amphibian (ICRP – Frog)	3.14E-02	7.99E+00	3.00E+00	2.50E+00
Benthic fish (FASSET Benthic fish)	1.47E+00	5.00E+01	8.01E+00	7.01E+00
Bird (ICRP Duck)	1.26E+00	3.00E+01	1.00E+01	8.02E+00
Crustacean (FASSET Crustacean)	1.57E-05	1.00E+00	3.00E-01	1.00E-01
Insect larvae (FASSET Insect larvae)	1.77E-05	1.50E+00	1.50E-01	1.50E-01
Mammal (FASSET Mammal)	3.90E+00	3.30E+01	1.50E+01	1.50E+01
Mollusc - bivalve (FASSET Bivalve mollusc)	7.07E-02	1.00E+01	4.50E+00	3.00E+00
Mollusc - gastropod (FASSET Gastropod)	3.53E-03	3.00E+00	1.50E+00	1.50E+00
Pelagic fish (ICRP Salmonid/Trout)	1.26E+00	5.00E+01	8.01E+00	6.01E+00
Phytoplankton (ERICA Phytoplankton)[15]	1.00E-06	7.97E-03	7.01E-04	7.01E-04
Reptile (ERICA Freshwater reptile) [16]	1.00E+00	1.80E+01	1.20E+01	6.00E+00
Vascular plant (FASSET Vascular plant)	1.05E-03	1.00E+02	1.00E-01	2.00E-01
Zooplankton (FASSET Zooplankton)	2.35E-06	2.00E-01	1.40E-01	1.60E-01

[16] Representative of adult female European pond turtle (*Emys orbicularis*).

APPENDIX F REPRESENTATION OF LOCAL SPECIES

Table F-29 Representation of Local Species by ERICA Reference Organisms.

ERICA Reference Organism	Local Species Examples [Ref 1]
Terrestrial ecosystem	
Amphibian (ICRP Frog)	Natterjack toads (*Epidalea calamita*), Great crested newt *Triturus cristatus*
Annelid (ICRP Earthworm)	
Arthropod – detritivorous (FASSET Woodlouse)	
Bird (ICRP Duck)	Avocet (*Recurvirostra avosetta*), Barn owl (*Tyto alba*), Bittern (Botaurus stellaris), Black redstart (*Phoenicurus ochruros*), Cetti's warbler (*Cettia cetti*), Crossbill (*Loxia curvirostra*), Gadwall (Anas strepera), Hobby (*Falco subbuteo*), Kingfisher (*Alcedo atthis*), Lesser black-backed gull (Larus fuscus), Little tern (*Sterna albifrons*), Marsh Harrier (*Circus aeruginosus*), Nightjar (*Caprimulgus europaeus*), Redshank (*Tringa tetanus*), Red-throated diver (*Gavia stellate*), Ruff (*Philomachus pugnax*), Sandwich tern (*Sterna sandvicensis*), Shoveler (*Anas clypeata*), Teal (*Anas crecca*), Whitefronted Goose (*Anser albifrons*), Woodlark (*Lullula arborea*)
Flying insects (ICRP Bee)	Norfolk hawker dragonfly (*Aeshna isosceles*), Soldier fly (*Odontomyia ornate*), Tachinid fly (*Subclytia rotundiventris*), White Admiral butterfly (*Limenitis camilla*)
Grasses & Herbs (ICRP Wild grass)	Sea sandwort (*Honckenya peploides*), Sea beet (*Beta vulgaris ssp. Maritime*), Atlantic salt meadows (*Glauco-Puccinellietalia maritimae*)
Lichen & bryophytes (ERICA Bryophyte)	
Mammal - large (ICRP deer)	
Mammal – small burrowing (ICRP Rat)	Water vole (*Arvicola amphibious*)
Mollusc – gastropod (ERICA snail)	
Reptile (ERICA snake)	Adder (*Viper berus*), Common lizard (*Zootoca vivipara*), Grass snake (*Natrix natrix*), Slow worm (*Angulis fragilis*)
Shrub (ICRP Wild grass)	Bell heather (*Erica cinerea*), Heather (*Calluna vulgaris*), Western gorse (*Ulex gallii*)
Tree (ICRP Pine Tree)	Oak (*Quercus spp.*)
Freshwater Ecosystem	
Amphibian (ICRP Frog)	Natterjack toads (*Epidalea calamita*)
Benthic fish (FASSET Benthic fish)	Eel (*Anguilla anguilla*)
Bird (ICRP Duck)	Bittern (*Botaurus stellaris*), Gadwall (*Anas strepera*), Lesser black-backed gull (*Larus fuscus*), Redshank (*Tringa tetanus*), Ruff (*Philomachus pugnax*), Shoveler (*Anas clypeata*), Teal (*Anas crecca*), White fronted Goose (*Anser albifrons*), Red-throated diver (*Gavia stellate*)
Crustacean (FASSET Crustacean)	
Insect larvae (FASSET Insect larvae)	
Mammal (FASSET Mammal)	Otter (*Lutra lutra*), Water vole (*Arvicola amphibious*)
Mollusc – bivalve (FASSET Bivalve mollusc)	
Mollusc –gastropod (FASSET Gastropod)	
Pelagic fish (ICRP Salmonid/Trout)	
Phytoplankton (ERICA Phytoplankton)	
Reptile (ERICA Freshwater Reptile)	
Vascular plant (FASSET Vascular plant)	
Zooplankton (FASSET Zooplankton)	
Marine Ecosystem	
(Wading) bird (ICRP Duck)	Avocet (*Recurvirostra avosetta*), Bittern (*Botaurus stellaris*), Gadwall (*Anas strepera*), Lesser black-backed gull (*Larus fuscus*), Redshank (*Tringa tetanus*), Red-throated diver (*Gavia stellate*), Ruff (*Philomachus pugnax*), Sandwich tern (*Sterna sandvicensis*), Shoveler (*Anas clypeata*), Teal (*Anas crecca*), Whitefronted Goose (*Anser albifrons*)

ERICA Reference Organism	Local Species Examples [Ref 1]
Benthic fish (ICRP Flat fish)	Eel (*Anguilla anguilla*), Plaice (*Pleuronectes platessa*), Sandeel (Ammodytes tobianus), Sole (*Solea solea*)
Crustacean (ICRP Crab)	Brown (edible) crab (*Cancer pagurus*), Lobster (*Homarus gammarus*)
Macroalgae (ICRP Brown seaweed)	
Mammal (FASSET Mammal)	Harbour porpoise (*Phocoena phocoena*)
Mollusc – bivalve (FASSET Benthic mollusc)	*Clam (Nucula nitidosa), Clam (Nucula nucleus), W*helk (*Buccinium undatum*), Whelk (*Buccinium undatum*)
Pelagic fish (FASSET Pelagic fish)	Bass (*Dicentrachus labrax*), Cod (*Gadus morhua*), Grey mullet (*Chelon labrosus*), Herring (*Clupea harengus*), Mackerel (*Scomber scombrus*), Sea trout (*Salmo trutta trutta*), Sprat (*Sprattus sprattus*), Whiting (Merlan*guis merlangus*)
Phytoplankton (ERICA Phytoplankton)	
Polychaete worm (FASSET Benthic worm)	Polychaete worm (*Nephtys hombergii*), Ross worm (*Sabellaria spinulosa*).
Sea anemones and true corals (ICRP Polyp)	
Vascular plant (FASSET Vascular plant)	
Zooplankton (FASSET Zooplankton)	

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